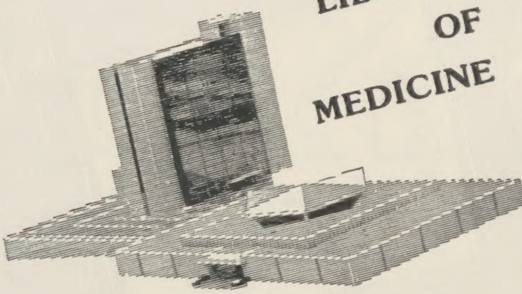

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A

TREATISE ON SURGERY

BY

AMERICAN AUTHORS.

FOR STUDENTS AND PRACTITIONERS OF SURGERY AND MEDICINE.

EDITED BY

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VOLUME I.

GENERAL SURGERY.

WITH 356 ENGRAVINGS AND 21 FULL-PAGE PLATES IN COLORS AND MONOCHROME.

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PREFACE.

In preparing a new treatise on Surgery it was evident that the surest method of achieving success was to invoke the collaboration of those who unite the qualifications of teachers in our leading colleges with abundant experience in private practice and in hospital clinics. It has been the agreeable duty of the Editor to secure this co-operation, and the distinguished names which adorn the several chapters of the work not only show how zealously this assistance has been rendered by the most eminent members of the profession, but offer the best guarantee of the value of the teachings embodied in the following pages.

The wonderful advance in both the science and art of Surgery during recent years has rendered advisable a departure from tradition, and the treatment bestowed on certain topics is therefore essentially new. This is the case, for instance, with the distinction everywhere maintained between hyperæmia and inflammation (*i. e.* infection). Chapters have been inserted on subjects not hitherto discussed in general treatises on Surgery—notably that on the Surgical Pathology of the Blood, introduced partly because of a decided conviction that the exact methods of clinical study so useful to the modern physician should not be denied to his surgical confrère. The chapters on Auto-intoxications and on the Surgical Sequelæ of Acute Non-surgical Diseases are also practically new. The importance of Bacteriology is everywhere recognized, and its teachings are impressed upon almost every page. In thus presenting the most recent results of research and experience, however, care has been taken not to neglect the vast amount of accumulated knowledge which is our heritage from the past, and unremitting effort has been devoted to afford under each topic a complete and condensed account of theory and practice representing the science and art of Surgery in the advanced position of to-day. Recent years have witnessed corresponding progress in medical education toward the highest standards, and this tendency to a beneficent uniformity renders practicable the preparation of a text-book answering the requirements of the continually increasing proportion of students who seek the advantages of our best institutions. Their needs cannot be sharply differentiated from those of the student after graduation; hence it is believed that the present volumes will be found serviceable in affording full practical information to the surgeon,

and to the general physician whose duties frequently call for surgical knowledge.

The first volume will be found to contain the more general subjects of Surgical Pathology, the General Principles and Theory of Surgery, and the Surgery of the Tissues and Tissue-systems, the particular applications of general surgery to the Surgery of Regions and Organs being reserved for the second volume. As each volume may be procured separately, the needs of all classes of readers will thus be met. Especial care has been devoted to the very complete series of illustrations, of which by far the greater part have been prepared expressly for the work, and colored plates have been introduced wherever they would best serve to elucidate the text.

In conclusion, the Editor desires to express his warmest thanks to the eminent contributors, whose zealous association in the production of the work will remain one of the most cherished recollections of a busy life. He would also express his indebtedness to Charles E. Smith, Esq., of Philadelphia for the careful supervision of the proof, and to Dr. Chauncey P. Smith of Buffalo for invaluable assistance throughout the preparation of the work.

ROSWELL PARK.

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GENERAL SURGERY.

PART I.

SURGICAL PATHOLOGY.

CHAPTER I.

HYPERÆMIA: ITS CONSEQUENCES AND TREATMENT.

By Roswell Park, M.D.

The reactionary results of injury to various tissues and the first local appearances due to the surgical infectious diseases are indicated by certain appearances which, for a few hours at least, are in large measure common to both. Their beginnings being pathologically similar, their results depend not alone on the violence or intensity of the process, but in predominating measure upon the primary influences at work. The consequences of mere mechanical injury—such as strain, laceration, etc.—are in healthy individuals promptly repaired by processes which will be taken into consideration in the ensuing chapters. They are throughout conservative and reparative, and are directed toward restoring, so far as possible, the original condition. The consequences, on the other hand, of the surgical infections are more or less disastrous from the outset, although the extent of the disaster may be localized within a very small area, as after a trifling furuncle, or they may be so widespread as to disable a limb or an organ, or they may even be fatal. It is of the greatest importance, not alone for scientific reasons, but because treatment must in large measure depend upon the underlying conditions, to differentiate between these two general classes of disturbance, which we speak of as—

A. *Those produced by external or extrinsic disturbances — i. e.* traumatisms, sprains, lacerations, etc.; and

B. *Those produced by internal and intrinsic causes,* which, for the most part, are the now well-known micro-organisms, such as produce the various surgical diseases.

These latter disturbances may be imitated or *simulated* in the presence of certain irritants within the tissues, such as the poisons of various insects and plants; the irritation produced by foreign bodies,

minute or large; and possibly the presence within the system of certain poisons whose nature is not yet known, such as that of syphilis or certain others whose chemistry is fairly well understood, but whose presence cannot be easily explained, as uric acid, etc.

Clinically, all these disturbances are manifested by certain phenomena common to each which may present themselves at one time more prominently, at another time less so. These significant appearances have been recognized from time immemorial as the *calor, rubor, dolor, tumor, et functio læsa* of our ancestors, or as the heat, redness, pain, swelling, and loss of function of our common experience. When one or more of these are present, the surgeon cannot afford to disregard the fact, while he should, moreover, be able to account for each on general principles which should to him be well known.

To their more exact study we must, however, make some preface in the way of general remarks concerning a phenomenon everywhere easily recognized, but as yet incompletely understood. This phenomenon has reference to an undue supply of blood to a part, and is commonly known under two terms which are practically synonymous—namely, *congestion* and *hyperæmia.* To begin with these, then, we must note, first of all, that congestion and hyperæmia may be—

A. *Active;* and

B. *Passive.*

They may also be spoken of as—

1. *Acute;* and
2. *Chronic.*

Considering first the two latter distinctions, it will be found that the acute hyperæmias are met with most often in consequence of sharp mechanical disturbances. The chronic hyperæmias, on the contrary, are conditions which in many individuals are more or less permanent. Note accurately here the proper significance of certain terms. Hyperæmia means, in effect, an over-supply of blood to the given part: the term should have only a local significance. When the entire body seems to be too well supplied with blood, the condition is known as *plethora*, the counterpart of which term is usually *anæmia.* The direct counterpart of the term *hyperæmia* should perhaps be *ischæmia*, meaning a perverted blood-supply in reduced amount. With plethora and anæmia as terms implying general conditions, with hyperæmia and ischæmia implying local conditions, there should be little room for confusion in phraseology.

The active form of hyperæmia used to be called "fluxion," a term now rarely used. *Active hyperæmia* means an increased supply of *arterial* blood. In *passive hyperæmia* the over-supply is rather of *venous* blood. In the former case the condition seems due to over-activity of the heart, with such local tissue-changes as permit it to occur. In passive hyperæmia the blood-current is slower—there is a tendency toward, and sometimes there is actual, stagnation; all of which is usually due to obstruction to the return of blood to the heart. The conditions permitting these two results may be widely variant.

Active hyperæmia may be produced by purely nervous influences, even those of emotional origin. The flushing of the face which is

known as "blushing" is, perhaps, the most common illustration of this fact. It is well known also that this is, in some degree at least, the result of division of certain nerves which have to do with the regulation of the blood-supply. The cervical sympathetic is the best known and most often studied of these, and the consequences of division of this nerve in the neck are stated in all the text-books on physiology. So also by electrical stimulation of certain nerves the parts supplied by them can be made to show a very active hyperæmia, which will subside shortly after discontinuance of stimulation, providing this has not been kept up too long. In active hyperæmia there is absolute increase of intra-arterial tension, and under these circumstances pulsation may be noted in those small vessels where commonly it is not seen nor felt. This is the explanation of the throbbing pain complained of under many actively hyperæmic conditions. This hyperæmia affords the explanation of the clinical signs to which attention has already been called. The increased heat of the part is the result of greater access of blood, which prevents cooling by radiation and evaporation: the peculiar redness is due to the greater filling of the capillaries with the blood, which gives the peculiar hue to the skin and visible textures; while to the increased pressure upon sensory nerves is also due the pain. The minuter changes occurring within the congested part call for more accurate description. Whether or not there be actual dilatation of capillaries under these circumstances is a matter still under dispute, but of the dilatation of the larger vessels there can be no possible question.

The phenomena attending the circulation of the blood through the involved part can be now succinctly stated, because they are observable in the mesentery of a frog, for instance, under the microscope. What is observed under these circumstances can be summarized as follows: An enlargement in the calibre of the vessels and a temporary increase in the amount of blood present, as well as in the rapidity of its flow—*i. e.* an increase in the blood-pressure with more or less stretching of the blood-vessels. Under these circumstances the vessel-walls easily leak, and the fluid portions of the blood ooze out between the cells of the vessel-walls, as water may leak through cracks in a hose, especially if the pressure be increased. When the blood-plasma escapes or virtually leaks out in this way, it produces a condition of watery infiltration of tissues which is known generally as *œdema*. When this fluid escapes into a previously existing cavity, it constitutes a dropsy of that cavity, to which in various parts of the body various particulate names are assigned.

As hyperæmia is to such a great extent brought about by action of the nervous system, it is well to divide it more accurately into the hyperæmia of paralysis, or *neuroparalytic congestion*, which is the result of a paralysis of the constrictor fibres of the vasomotor system, and into the hyperæmia of irritation, or *neurotonic congestion*, which is due to the irritation of the dilators (Recklinghausen). Physiologists are are fairly well agreed that as between the dilating and constricting apparatus of the vasomotor system there is ordinarily preserved a certain degree of equilibrium; to which fact it is probably due that a normal condition of affairs is brought about after temporary disturb-

ance, since, too, over-action in one direction succeeds reaction in the other. As Warren has illustrated this, our common treatment of frost-bite by cold applications is a concession to this fact, since by the cold application we endeavor to limit the reaction which would otherwise follow after thawing out the frozen part.

The best examples of the *hyperæmia of paralysis* are perhaps to be met with after certain injuries to nerves, as, for instance, flushing of the face and hypersecretion of nasal mucus, tears, etc. after injury to the cervical sympathetic. Such too, in its essentials, is that form of shock known as brain-concussion, which is often followed by nutritive disturbances among the brain-cells, with consequent perversion of brain-function.

Waller's experiment of placing a freezing mixture over the ulnar nerve at the back of the elbow is also significant, the result being congestion and elevation of surface temperature of the fingers supplied by this nerve. Congestion and swelling have also been observed after fracture of the internal condyle of the humerus, by which this nerve was pressed upon; and similar phenomena may be noted in fingers or toes as the result of injuries of other nerves.

Hyperæmia due to *paralysis of the perivascular ganglia* is observed sometimes in transplanted flaps, in the suffusion of a limb after removal of the Esmarch bandage, in the congestions of certain sac-walls after tapping, in the hyperæmia, perhaps even hemorrhage, from the bladder-wall after too quickly relieving its over-distention, in the swelling of the extremities when they begin to be first used after having been put at rest because of injury, etc.

The *hyperæmias of dilatation* are more acute in course and manifestation. Along with them go sharp pain, hypersecretion of glands, œdema, and sometimes desquamation of superficial parts. The facial blush due to effusion; the temporary flushing due to indulgence in alcohol; the suffusion of the conjunctiva, perhaps the face, with hyperlachrymation, accompanying facial neuralgia or hemicrania; and the hyperæmia consequent upon herpes zoster, urticaria, etc., are illustrative examples of this form. The erythema due to nerve irritation or injury, the swelling of the joints which appears after similar lesions, and that condition described by Mitchell as *erythromelalgia*, probably also belong here. In fact, almost all the reflex hyperæmias are hyperæmias of dilatation.

In those instances which are numerically more common, where the cause of the hyperæmia is temporary or evanescent, the appearances above described vanish perhaps almost as quickly as they appear. If the congestion be both intense and last a few hours, or even less, we get a temporary œdema, such as most writers call *collateral*, which is particularly noticeable in soft tissues. Even such separations of vascular walls as shall permit escape of blood—*i. e.* hemorrhage—may be the result of simple hyperæmia without changes which necessitate elaborate further description. Hemorrhagic exudates, seen especially in certain skin diseases and on mucous surfaces, are the best examples of this condition. A more or less continuous hyperæmia means an increased amount of nutritive material, the result of whose presence is increase of tissue-elements by that form of overgrowth which will be later dealt with as *hypertrophy* and *hyperplasia*.

The forms of hyperæmia considered above belong mainly to the designation of *active*. **Passive hyperæmia** is most often a mechanical consequence of obstruction to return of blood which can be imitated at will, and which is not infrequently the result of sheer carelessness, as when an injured limb is bandaged too tightly. Experiment shows that when such mechanical obstruction has taken place there is temporary increase of intravenous pressure, which soon returns to the normal standard, such readjustment meaning that blood has found its way back by collateral circulation. Only when such rearrangement is possible do we have anything like permanent passive hyperæmia. In organs with a single vein, such as the kidneys, the question of obstruction may assume a very important aspect. Under these circumstances the appearance of the involved part, when visible, is spoken of as *cyanotic*, while its surface instead of being abnormally warm is the reverse, due to impeded access of warm blood and more rapid surface-cooling. The blood under such conditions is often darker than natural, because, remaining longer in the part, it absorbs more carbonic dioxide or at least gives up more of its oxygen. So long as actual gangrene is not threatened, the blood-column has a communicated pulsation, at least in the large veins. Escape of corpuscular elements may occur after the phenomena above noted have been present for some time; but the corpuscles rarely, if ever, escape until there has been more or less copious transudation of the fluid portion of the blood—*i. e.* the serum. When anatomical changes can be grossly yet carefully observed, as in the fundus of the eye, it is seen that under these circumstances the arteries become smaller, although whether this be a primary or secondary change is not to be made out. Discoloration of the integument is the frequent result of leakage of blood-corpuscles and their pigmentary substance into the tissues, and is consequently a frequent accompaniment of chronic passive œdema. It is seen very often in connection with varicose veins of the legs.

Another form of passive congestion or hyperæmia is that due to enfeeblement of the heart's action by serious injury or wasting disease. When under these circumstances the lung has become more or less infiltrated with fluid, with hemorrhagic extravasation, the condition is known as *hypostatic pneumonia*—a misnomer, nevertheless indicating a condition which is only too frequent in the aged and feeble.

Results of Hyperæmia and Congestion.

These may be—

1. Speedy Subsidence of all Hyperæmic Phenomena—Resolution.
2. Acute Swelling.
3. Chronic Enlargement.
4. Gangrene.
5. Nutritional Changes—Atrophy and Hypertrophy.

1. The **speedy subsidence** of hyperæmic phenomena is often known as **resolution**—a term which has also been applied to the retrograde phenomena after a genuine inflammation. For present purposes it implies, first, the subsidence into inactivity of the exciting cause or its complete removal. This may include the passing of an emotion, the removal of an irritant, the loosening of a bandage, the resort to

certain applications or to constringing or astringing measures by which the effect is counteracted. A particle of dust in the conjunctiva may within a very few moments produce a very active congestion of the conjunctival vessels, which, ordinarily scarcely visible, become now prominent and easily noted. The removal of the offending substance permits a prompt return to their original size, and all this may be a matter of perhaps half an hour. This is an example of the speedy subsidence of the hyperæmia of dilatation after removal of the cause. Should the hyperæmia not subside at once, it is well known what aid may be gathered from cold applications, or in this instance from some gentle astringent collyrium, or from some agent whose physiological effect it is to produce contraction of vessels, such as cocaine.

2. **Acute Swelling.**—When the effusion above referred to takes place into loose connective tissues the condition is spoken of technically as *œdema*, while when it occurs into a previously existing cavity, such as that of a joint, it is known as an *effusion*. The amount of blood thus effused will be in large degree influenced by the anatomical and mechanical conditions obtaining about the part. It may be laid down as a general rule that when the extravascular pressure equals the intravascular pressure little or no more fluid may escape. As a matter of fact, it is seldom that the former even rises to the degree of the latter. Conversely, one method of treating such œdemas and effusions is by some device which shall make the extravascular pressure exceed the intravascular, when the fluid is, as it were, forced back into the vessels, and is made to resume its proper place within the same. This is often done by taking advantage of elastic compression, as when a rubber bandage is applied about the part. In certain parts of the body it may be done by pressure brought about by some other device. Pressure may be used practically for two purposes:

A. To so increase extravascular pressure as to limit the possible amount of an effusion, as when it is put on early after an injury; or,

B. When it is used as a later resort for the purpose of reducing swelling which has already occurred.

An ideal illustration of an acute swelling is that afforded by a sprain of a joint. As the result of the mechanical injury, and probably of activity of special nerves supplying the part, there is brought about an active hyperæmia of dilatation whose consequence is a prompt effusion. How easy it may be to limit this by pressure, made early, is as well known as that swelling may be speedily reduced in size by resort to the same method later.

3. **Chronic Swelling.**—This is something more than the swelling alluded to under *Acute Swelling*. Chronic swelling implies either a continuous passive hyperæmia, or, what is much more common, a positive increase in tissue-elements as the result of an over-supply of nutrition brought by the blood, which itself was furnished to the part in a degree far in excess of its needs. The result is a more rapid reproduction of cell-elements, with result in the shape of tissue-thickenings or tissue-enlargements, which are to the laity known as "overgrowth," or to us as *hypertrophy*, or, more properly speaking, *hyperplasia*, of a part. This chronic swelling or chronic enlargement is in

some degree also connected with the phenomena of escape of white corpuscles from the blood-vessels and mitotic division of certain tissue-cells, which have up to this time been usually regarded as so distinctive a feature of the true inflammatory process. This will be taken up in greater detail a little farther on; but, nevertheless, it is necessary to emphasize just here that hyperplasia or chronic enlargement of the part may be the result of hyperæmia alone, without necessarily invoking the presence of elements which have escaped from within the blood-vessels as the result of excess of nutritive supply.

4. **Gangrene.**—This may be the result of sheer hyperæmia—for the most part the passive forms—though most instances of gangrene due to intrinsic causes are inseparable from the presence of infectious micro-organisms. The gangrene which is spoken of here would include that due to the pressure of tumors, tight dressings, or any natural or intrinsic agency, and that due to pressure from without when not so pronounced as to produce immediate and total loss of circulation in a part. It includes the formation of many bed-sores and so-called *pressure-sores*, which may be due to an enfeebled heart, to an obstructed pulmonary circulation, or to external pressure in conjunction with cardiac debility. While insisting, then, that gangrene be recognized in this place as a possible result of hyperæmia, it should be added that gangrene is in effect a tissue-death, and that dead tissue is always and everywhere practically the same thing, no matter by what causes brought about. Consequently, the subject of gangrene will be considered under a heading by itself.

There should also be included here the possible evil consequences of too active interference in the presence of threatened harm as the result of passive hyperæmia due to pressure. When external pressure is removed, but little possible harm may come, probably only benefit; but when internal pressure is too speedily removed, disaster sometimes occurs, and from various causes. It is often necessary also to provide some external pressure which shall in some measure compensate for the changed conditions brought about by relief of internal. To illustrate: After aspirating a joint distended by an acute effusion it is always well to equalize pressure by a suitably graduated (preferably elastic) compression from without, by which a repetition of effusion shall be avoided. Indirectly also caution should always be exerted in aspirating a full chest for the relief of a pleural effusion which is the result of passive hyperæmia, since not infrequently the heart is materially displaced by the accumulated fluid, and such rapid readjustment of its position as might be brought about by a too sudden removal of fluid might entail upon it more strain than it could bear without syncope or complete cessation of activity Or a greater source of danger is that of œdema of the lung or possible dislodgement of thrombi or emboli from relaxation of pressure. So, too, after tapping certain spinæ bifidæ, more particularly after incision and evacuation of their contents, the sudden removal of intraspinal pressure might produce disastrous effects in the brain and cord, did one not take the precaution to have the patient with the head down, so that the intracranial hydrostatic pressure might be disturbed as little as possible.

5. **Nutritional changes** will be considered by themselves a little later.

The consequence of persistent hyperæmia is **exudation**—*i. e. escape of blood-plasma from the vessels into body-cavities and tissue-interspaces.* This leads to consideration under a distinct heading of

Exudates.

Exudation may occur alike in vascular and non-vascular, in firm and soft tissues, in, under, and upon membranes. With respect to location, exudates are described as *free* when found upon free surfaces or within natural cavities; *interstitial* when found between the tissues or parts of tissues; and *parenchymatous* when they are situated within the tissues themselves, particularly in epithelial and glandular cells of any kind.

As concerns quality, exudates are *serous*, *mucous*, *fibrinous*, or *mixed*, the mixed forms including the so-called *sero-purulent*, the *muco-purulent*, the *croupous*, and the *diphtheritic*, as they used to be mentioned by the older writers. When any exudate contains red globules in sufficient quantity to stain it, it is called *hemorrhagic*.

Serous exudates from free surfaces are sometimes spoken of as serous *catarrhs;* when into cavities, as *dropsies;* when into tissues, as *œdema;* when occurring beneath the epidermis they form *serous vesicles* or *blebs* or *bullæ*.

The best example of *catarrhal* exudate perhaps is furnished by the copious secretion from the nose in cases of acute coryza. *Serous* exudates are in all probability regulated, to at least some degree, by nerve-action. This is particularly evident after ligation of the submaxillary duct with irritation of the chorda tympani. After secretion is exhausted there sets in a speedy œdema of the gland itself.

Mucous exudate differs little from normal mucus, save that it is sometimes thicker or usually thinner. Occurring from mucous membranes, it forms the ordinary mucous catarrh.

Fibrinous exudation refers to the fluid which coagulates soon after its exit from the vessels within those spaces into which it has oozed. When flocculi of coagula float in serous fluid it is known as a *sero-fibrinous* exudate. Pure fibrinous exudate occurs relatively rarely, save in and upon mucous membranes. The extent to which exposure to the air is responsible for the firm coagulation of the fibrin previously held in solution is uncertain. The most potent factors in producing such coagulation are bacteria, but it is not yet disproven that coagulation may occur without their aid. When such coagulation occurs upon the surface of a mucous membrane it has been spoken of as *croupous*. When the epithelial covering as well as the basement membrane, and often the submucous tissues, are involved so that now the membrane cannot be stripped off without tearing across minute blood-vessels, the exudate has been known as *diphtheritic*. These terms may possibly be still retained in an adjective sense as implying the exact location of a surface exudate, but are scarcely to be used in any other significance.

It is probable that the factor which mainly has to do with solidification of such fluid exudate as comes to the surface in fresh abrasions or in larger superficial wounds, by whose desiccation is produced the so-called scab or crust, is simple exposure to the air. It is, at all events, a conservative process in most instances, since by drying a thin but sufficient protection is afforded for the delicate reparative processes which go on beneath, these including proliferation of epithelium from the periphery of the lesion and formation of delicate granulations from the mesoblastic tissues. Fibrinous exudates may also undergo *fatty degeneration* or *fatty metamorphosis*, and sometimes *calcification*, the latter being simply a deposition of the calcium salts which are held in solution in the sur-

rounding fluids. Resorption of fibrinous exudate also occurs, probably by means of a liquefaction brought about by agencies whose minute chemistry is not yet known.

So soon as an exudate becomes exposed to contact with air or with many of the body-secretions, there is danger of its prompt infection by means of micro-organisms. These may enter from within or from without, as is shown in the next chapter. The prompt effect of such exposure is the conversion of a non-purulent exudate into *pus*, which means that the gross lesion is now altered from one of simple hyperæmia with its natural sequence into one of true inflammation with suppuration. This conversion of fluid or solid exudate, whether active or passive, into pus is seen very often, as, for instance, in joints, in the pleural cavity, etc. Along with the concealed microscopic and chemical changes going on within the tissues, there are also phenomena which are usually easy of recognition, and which more or less completely alter the clinical type of the case in hand.

The following table illustrates significant differences whose full importance cannot be impressed before a study of inflammation has been carefully entered upon:

Hyperæmic Exudates.	Inflammatory Exudates.
Poor in albumen.	Rich in albumen.
Rarely coagulate in the tissues.	Usually coagulate in the tissues.
Contain few cells.	Contain numerous cells.
Low specific gravity.	High specific gravity.
Contain no peptone.	Contain peptone (product of cell-disintegration).

Symptoms and Treatment of Congestion and Hyperæmia.

The principal clinical characteristics of these conditions have been already mentioned. They may be summarized as *redness*, which is due to increased amount of blood in the part, the color varying in intensity according as arterial or venous blood predominates in the part, and the tint deepening as the blood-current slackens. It is under these circumstances, with excess of tension and overcrowded capillaries, that a sufficient number of red corpuscles escape into the exudate to produce the so-called hemorrhagic form of exudate and the punctate ecchymosis characteristic of certain eruptions. Ordinarily in the presence of abundant exudation redness is diminished. Naturally, mucous membranes show these colors better than the skin. The most perfect visible type of disturbance of this kind may be seen in the conjunctiva, when vessels become easily visible which ordinarily are not perceived.

Swelling has already been explained as due to distention of blood-vessels and escape of their contents in the shape of exudation. Not infrequently it occurs that an innocent exudation into the superficial parts accompanies unmistakable and more serious affection of the deeper. This is known as *collateral œdema*. The condition known as hepatization is simply infiltration of more soft and distensible organs or tissue with exudates which partially or completely solidify.

The *pain* is simply an expression of pressure upon terminal sensory nerves, and differs within the widest possible degrees. Loose and distensible tissues will easily expand to accommodate the increasing exu-

dation, and there will be but a minimum of pain. Tissues covered with firm, resisting membranes, like bone, prostate, testicle, fundus oculi, etc., will cause intense, even agonizing, pain upon a minimum of distention. The throbbing pain so often complained of is due to the added heart-pressure of systole upon sensitive nerves. Throbbing pain is seldom complained of in mere congestion or hyperæmia; it is usually rather a sign of infection and threatening suppuration. It is a law of neuro-physiology that irritation along the course of a nerve is or may be referred to its terminal distribution, and this fact is often demonstrated in studying the complaints made by the patient. Pain may also radiate upward and involve parts above the level of the lesion.

Heat—*i. e.* increase of local surface temperature—is the fourth external symptom of congestion. This is usually easily recognized by the palpating hand. It is due to local hyperæmia, and still more to local infections—*i. e.* inflammations. The temperature of the affected part is in the main proportionate to the degree of hyperæmia.

Along with these manifestations of local disturbance, which if they attain any degree are recognizable at once, there is the fifth symptom of *disturbed function* of the part with which older writers used to deal so much; the congested part is temporarily disabled in partial or complete degree. Its sensitiveness is augmented: that gives extreme pain or cannot be tolerated which under other circumstances would cause no sensation whatever. The disturbance of function is in the main proportionate also to the degree of the lesion, and in non-hysterical or non-neurotic subjects a fair estimate can be made by noting the functional disturbance.

Treatment.—These disturbances are to be combated, first of all, by insisting upon *physiological rest.* This, perhaps, is the most important measure of all. The profession is greatly indebted to Hilton for the decided advance which he made in the treatment of congestive and inflammatory affections by insisting upon this principle in his celebrated work on *Rest and Pain*, which every young practitioner should read. Aside from this first and underlying principle, the treatment must, in some measure at least, be based upon the time at which we are called upon to treat the case. If seen at once, before exudation has been excessive or the other disturbances marked, we may carry out a certain line of treatment for the purpose of limiting all these unpleasant features. On the other hand, if seen late, when exudation has been copious and when pain and other disturbances are due to its presence, a distinctly different course will be adopted.

Toward the end first mentioned—namely, the limitation of hyperæmia—we may adopt local and general measures. Local measures include graduated pressure, providing this be not intolerable to the patient, endeavoring to so equalize pressure that outside of the vessels it shall equal that inside. This may be done by careful bandaging, extreme care being taken that the pressure be applied from the very extremity of the limb; otherwise, passive exudation might be augmented and gangrene be precipitated. Elevation of a limb will often accomplish much the same purpose. Cold, which is in effect an astringent and which tends to contract blood-vessels, is another measure in the same direction, and if applied early will do much to limit the degree of the attack. This may be applied as dry or moist cold, and should be gradually mitigated as the congestion subsides. It acts through the vasomotor system, and is a measure to be resorted to with some caution. An efficient way of applying dry cold can be extemporized by a few yards of rubber tubing, held in place by wire or sewed in place

to a piece of cloth, through which a stream of cold water is permitted to gently pass.

Heat is another efficient means, acting, however, in a rather different way. Heat is a measure to be employed to hasten the disappearance of exudation—in other words, to quicken resorption, which it does by equalizing blood-pressure, dilating the capillaries, stimulating the lymphatic current, and in every way helping to clear the tissues of that which has left the blood-vessels.

It is necessary also, at least in extreme cases, to employ some detergent or derivative measures, which include *blood-letting* as one not sufficiently resorted to. When done for this purpose, depletion should be carried out at the area involved if possible. This may be done either as venesection, by leeching either with the natural or the artificial leech, or by a series of minute punctures or incisions, which give relief to tension, permit the rapid escape of fluid exudate, and often save tissues from the disastrous effects of strangulation. In some cases of deep-seated congestions these measures are inapplicable, and venesection at the point of election—say the cephalic vein in the arm—may be followed by great benefit. Another method of depletion is by administration of cathartics, such intestinal activity being stimulated as shall lead to copious watery evacuations. The salines rank high as measures directed toward this end, but in emergency much stronger and more drastic drugs may be administered, such as jalap, calomel, elaterium, etc. Diaphoretics and diuretics help to reduce temperature, and in some degree to deplete, but their action is usually slow. When exudation is considerable in amount and confined to some one of the body-cavities, it is often best combated, if at all obstinate, by the method of *aspiration*. This includes any suitable suction apparatus by which the fluid may be withdrawn through a small needle or cannula, the operation being trifling in difficulty, but one to be performed under strictest aseptic precautions, lest infection of an exudate already at hand be permitted.

Certain individuals, especially the neurotic, will need more or less anodyne, particularly when local applications fail to give relief. Sometimes a small dose of morphia administered hypodermically will act like magic in making efficient those measures which would otherwise be inefficient. In little children also some anodyne or hypnotic will be of great service. Under all circumstances it is well to keep the lower bowel empty, and certain elderly individuals with weak and enfeebled hearts will need the stimulation to be afforded by digitalis, quinine, and alcohol, or preferably by strychnia administered subcutaneously.

In cases of chronic hyperæmia and its consequent hyperplasias (induration, thickening, etc.) there is no one measure so generally applicable and effective as the continued use of cold-water dressings. These are generally spoken of as "cold wet packs," and may be continued—constantly or intermittently—for many days.

On Atrophy and Hypertrophy, and the Consequences of Altered, Diminished, and Perverted Nutrition.

As a consequence of increase of nutrition we have produced a condition known commonly as *hypertrophy*, more accurately as *hyperplasia*. Hypertrophy literally means overgrowth, whereas hyperplasia more accurately describes that which constitutes hypertrophy—namely, numerical increase of constituent cells. Common usage has made the more inaccurate name "hypertrophy" cover nearly

all these conditions. *Hypertrophy* or hyperplasia *means enlargement of a part or of an organ beyond its usual limits*, and as the result of increased function or increased nutrition. It is to be distinguished from *gigantism*, which means inordinate enlargement as the result of a congenital tendency or condition. Hypertrophy is—

A. *Physiological*
1. Compensatory;
2. From deficient use.

B. *Pathological*
3. Local;
4. General;
5. Senile;
6. Congenital.

A. **Physiological Hypertrophy.**—1. This includes many of the compensatory enlargements of an organ or a part when extra work is put upon it owing to deficiency of some other organ or part. This is spoken of as *compensatory* enlargement. Illustrative examples may be seen in the heart, which becomes larger and stronger when the blood-vessel walls are diseased and their lumen narrowed or when other obstructions to circulation are brought about; again, in enlargement of one kidney after extirpation of the other, or of the wall of the stomach when the pylorus is constricted or obstructed; again, of the fibula after weakening or more or less destruction of the tibia, or of the shaft of any bone when it has been weakened at some point by not too acute disease; or, again, of the walls of bursæ after constant friction.

Fig. 1.

Congenital hypertrophy: gigantism of one extremity (Fischer).

Fig. 2.

Congenital hypertrophy: gigantism of both lower extremities (case of Dr. Graefe [Sandusky]).

2. The best examples of physiological hypertrophy owing to deficient use are perhaps seen in some of the lower animals; as, for instance, in the teeth of such rodents as beavers when kept in captivity and prevented from natural use.

FIG. 3.

Congenital hypertrophy: gigantism of both lower extremities (case of Dr. Graefe [Sandusky]).

B. **Pathological Hypertrophy.**—3, 4. Instances of this are everywhere and every day to be met in the results of so-called *chronic inflammation*, a term which is a complete misnomer and should be expunged from text-book use. So-called chronic inflammation simply means increase of nutrition owing to a certain degree of hyperæmia, which may have been produced in the first place as the result of traumatism, which may come from chemical irritants circulating in the fluids of the part—as, for example, uric acid, etc.—or which are brought about as the result of perverted trophic-nerve influence. Instances of local pathological hypertrophy may be seen in the thickened periosteum after injury, in the enlargement of a phalanx known as the "baseball finger," and in numerous other places; or they may be general, in which case they are brought about mainly by some irritating material in the general circulation. The unknown poison of syphilis notoriously provokes such nutritive disturbances.

5. *Senile hypertrophy* is connected with nutritional disturbances characteristic of old age, as to whose remote causes we are still in the dark. Instances of senile hypertrophy, however, are common, particularly in the prostates of elderly men, which are quite prone to undergo vexatious, and even vicious, enlargement.

6. Of *congenital* hypertrophy and that of unknown origin we see, for instance, examples in certain rare cases of hypertrophy of the breast, in leontiasis, perhaps even in acromegaly, etc.; and these are to be distinguished from *gigantism*, because in most instances of the former type the hypertrophic tendency is not manifested until youth or adult life, whereas gigantism is a condition in which the tendency was apparently manifested even before the birth of the individual.

ATROPHY.

Atrophy implies impaired nutrition, and means diminution in the size of an organ or part, and is the converse of hypertrophy. It is necessary to make plain that in atrophy nutrition is only impaired and not arrested, since complete arrest of nutrition means necrosis—*i. e.* gangrene. It may be—

A. *Physiological*
1. From Disuse without Disease;
2. Biological or Developmental;
3. Senile.

B. *Pathological*
4. Result of Acute Tissue-losses;
5. Result of Phagocytic Activity;
6. Result of Continuous Pressure;
7. Specific.

A. Physiological Atrophy.—1. This is always the result of disuse or impaired function from any cause. Its evidences are most quickly seen in the fatty structures and muscles—*i. e.* in the soft parts. It is true, however, even of the bones, or, of greater interest, even in the brain-cells. We see evidences of it also in minute organs; as, for example, in the digestive glands in certain cases where diet is restricted. Again, we see it in the diminution of the size of the heart after hip-amputation, less being required of that organ. Again, in the entire structure of the rectum after colostomy.

2. Examples of the *developmental type* are best seen in the natural disappearance of the hypogastric arteries, the ductus arteriosus, the vitelline duct, the Wolffian bodies, and in the various generative ducts (Gärtner's, etc.) shortly after birth of the human individual. We see it also in the prostate after double orchidectomy. Equally illustrative is the disappearance of the tail and gills of the tadpole, the eyes of animals living in caverns, and, in a general way, of organs which become useless owing to a different environment.

3. *Senile* atrophy is seen equally well in the hair-follicles, the teeth, the bones, and the sexual organs of elderly people—in fact, in all their tissues, even in the brain.

B. Pathological Atrophy.—4. Very acute atrophy of surrounding tissues is the necessary accompaniment of destruction by suppurative or other disturbances; that is, parts disappear by absorption which have not been interfered with by pyogenic organisms. So complete may atrophy be under these circumstances as to cause disablement of an organ or part. This kind of senile disappearance is merely an expression of phagocytic activity, although not now a question of bacteria.

5. The same is true of that variety spoken of above as *biological*

or *developmental*, since phagocytes are the active agents in producing the disappearance of the tadpole's tail.

6. A more slow form of pathological atrophy is seen in the *gradual disappearance* of tissues in the neighborhood of advancing tumors, enlarging cysts, etc. This is perhaps but another expression of atrophy from continuous pressure. But a still better illustration is the atrophy which comes from immobilization of a part without pressure. This is notorious when splints or orthopædic apparatus have to be long kept in place. Other examples of slow atrophy from these conditions can be seen as the result of tight bandages or ill-fitting splints; again, in the distortion of the skull produced among the Flathead Indians by pressure, in the Chinese woman's foot, in the atrophy of the cord and testicle, as well as of other soft parts, which may be produced by the pad of a truss; in certain posture-deformities; in the paralysis of the arm known as "crutch paralysis" even after intermittent pressure upon crutches; in the deltoid paralyzed by injury to the circumflex nerve by the dislocated head of the humerus; and in the distant atrophy of limbs which is produced by pressure on main trunks of vessels or nerves from any of the above causes. These forms of atrophy are closely allied to or are identical with that which is often spoken of as absorption, but these are to be abruptly distinguished from the condition known as ulceration, implying such lowering of vital resistance as to permit of infection. Atrophy and absorption contravene the possibility of infection; ulceration always implies it.

7. *Specific* forms of pathological atrophy are largely connected with disturbances in the central nervous system. They are often spoken of as *trophoneurotic*. Their exact mechanism is not yet understood, and cases may be confused under this head whose remote causes are widely different. Here should be included, for instance, the atrophy of a deep bone which occurs after extensive burn of the surface; also that peculiar form of atrophy of tissues in the stump which produces the so-called *conical stump*. These cases are indeed of a more complicated character, since if pressure be removed from the bone-end, especially in young people, the bone tends to grow faster than it should, while the soft parts disappear, partly as the result of mere disuse or loss of function. In this way conicity is produced, which sometimes calls for subsequent reamputation. Under this head might also be included the so-called "trophic inflammation" (misnomer) of some writers, such, for example, as ulceration of the cornea after division of the trigeminus. The general subject of *atrophic elongation* also belongs here, referring to the fact that as a result of disuse, or sometimes of active disease, the bones, while showing atrophic changes in other respects, actually increase in length. Should such increase occur in one bone of those portions of the limbs which are supplied with two, the result would be posture-deformity and displacement of the terminal portion.

Treatment.—Hypertrophy may sometimes call for reduction by operative measures. Atrophy, on the other hand, calls for stimulation of nutrition in the affected parts by massage, electricity, cold douching, exercise, deep injections of strychnia, etc., after removal of the cause when possible.

CHAPTER II.

SURGICAL PATHOLOGY OF THE BLOOD.

By Roswell Park, M. D.

The part played by the constituent elements of the blood in inflammation, suppuration, and other still more disastrous conditions is so great and so important that, before proceeding to discussion of these lesions, it seems necessary to set forth a résumé of facts illustrating the importance of accurate knowledge concerning this most important fluid.

Thrombosis.

Thrombosis is a term applied to the formation of a *thrombus—i. e.* a clot within the cavity of the heart or one of the blood-vessels—the term being limited to coagulation of blood within these natural cavities, and without specifying the exciting cause of the same. A clot so formed is called a thrombus. To be accurate, a distinction should be made between a thrombus, which is always caused before death—or, rather, during life—and the *clot*, which is essentially a post-mortem affair. Our application, then, of the terms "thrombosis" and "thrombus" refers solely to that which takes place during life. In order to appreciate the conditions which lead to thrombosis it is necessary to fully appreciate the reciprocal conditions which must normally be maintained between the circulating blood and the walls of the vessels in which it flows. Fluidity of blood depends always upon integrity of the vessel-wall. So long as its lining membrane be absolutely undisturbed and normal, blood will never coagulate within it, and the only thrombi that may be met within it are those which are propagated from a distance. Coagulation of blood is for the most part associated with the peculiar properties of fibrin. Fibrin, it is now well established, is produced by the union of two substances, known as *fibrinogen* and *paraglobulin*, which union takes place as the result of the activity of the so-called fibrin-ferment. The fibrinogen is ordinarily kept in solution in the blood-serum ; all of the fibrin-ferment, and at least the greater part of the paraglobulin, are contained within the colorless blood-corpuscles, by whose disintegration they are released. Consequently, so long as nothing happens to the leucocytes, coagulation cannot occur. It seems to be one of the peculiar activities of the endothelial lining of vessels to restrain this very disintegration. Even when small quantities of fibrin-ferment are introduced from without, this membrane seems to have the power of rendering it inefficient, and large quantities introduced at once are necessary to artificially produce coagulation in this way. Physiological integrity of vascular walls, therefore, is inimical to thrombosis.

Causes.—The underlying *cause* of all *thrombi* is, then, *alteration*

of the endothelium. In consequence, when it is desirable to produce coagulation artificially advantage may be taken of this fact, and mechanical injury to the vessel-walls may be quickly followed by the desired results. Advantage is also taken of this fact in surgery, especially in certain methods of treating aneurism, by rude handling, by needling, by the introduction of horse-hairs, fine wires, etc.

While such endothelial lesions are essential, there are, nevertheless, numerous other accessory causes which must here be mentioned. These comprise—

A. The presence of foreign bodies, as, for example, needles, hooklets of echinococci, parasites, particles of tumors, fragments from the heart-valves, and, most of all, that which is essentially a foreign body, a clot which has come from some other point. Around such foreign particles, by the way, will quickly group themselves a relatively large number of other leucocytes, affording thus another example of phagocytosis, soon to be described. Mere slowing of blood-stream without some such mechanical irritation is not sufficient to produce coagulation. If, for instance, a section of vein be isolated between two ligatures, the ligation being aseptically done and the surroundings of the vein-wall disturbed as little as possible, the blood thus shut up within the vein remains fluid indefinitely. If, however, the vessel-wall be separated from its surroundings, so that its nourishment is compromised, the contained fluid quickly coagulates.

B. Necrosis, gangrene, etc. lead to quick involvement of the endothelium of the vessels contained within the involved part, and consequently quickly to coagulation of the blood which they contain.

C. Temperature has also an influence in the same direction, and extremes in either direction, or drying of vessels which may happen to be exposed to the air for some time, leads to the same results.

D. Inflammatory and degenerative processes occurring in and about the vessel-walls tend always to produce coagulation. This is well seen in the influence exerted by the so-called *atheromatous ulcers*—*i. e.* the degeneration of certain areas in the walls of large vessels.

E. Micro-organisms and their products are perhaps the most frequently effective of all the accessory causes of thrombosis. In other words, in all the surgical infectious diseases we may expect to find more or less, sometimes extensive, thrombosis in the vessels of the affected part. This may so far shut off circulation as to lead to gangrene, which may be local or may terminate the life of the patient.

Also, in some of the infectious diseases not ordinarily considered surgical we see similar conditions, and thrombosis is not an infrequent sequel of the puerperal condition, typhoid fever, etc. The condition is also well marked in certain cases of infectious endocarditis, which is very often followed by thrombosis and pyæmia as a complication, the latter being due to the septic character of the micro-organisms at fault.

Thrombi are classified as—

1. *Primary;* and
2. *Propagated.*

The *primary* thrombus is one which has originated at the spot where it has been first produced, and is usually coextensive with its cause. The propagated thrombus may be one which has been carried to

a considerable distance, and is met with at a point widely different from that where it originated, or one which has extended along the vascular channel in which it was first formed, but far beyond the limits of its prime cause. When a thrombus attaches itself to a part of the vessel-wall it is called *parietal or valvular*, because it does not completely occlude the vessel; when it involves the entire circumference of the vessel, but does not completely occlude it, it is spoken of as *annular*. The *obstructive* thrombus is that which completely fills a given vessel and shuts off all circulation through it.

The *propagated* thrombus extends usually in both directions, and always much farther in veins than in arteries. Thus, thrombi may be met with extending from the ankles even into the inferior vena cava. The venous valves, which, on the one hand, may excite coagulation, on the other hand tend to fix the coagula more firmly in their place. In arteries thrombi usually extend finally to the first collateral channel on the cardiac side, but occasionally they extend farther. The *cause of a primary thrombus* is to be *sought for at the site of its lodgement*; the *cause of propagated thrombi* is often to be met with *at wide distance from the effect.*

Thrombosis is, again, to be spoken of as—

a. Marasmic;
b. Mechanical or traumatic;
c. Infective.

a. The *marasmic* forms are due to essential alterations in the constituents of the blood, which for the most part are due to starvation or wasting disease. Marasmic thrombi seldom give rise to serious disturbance during life until the condition is so complex and serious that the patient is at death's door. Post-mortem evidences of marasmic thrombi, however, are often found, and yet have but little surgical significance. They are seen perhaps as often in the cranial sinuses as anywhere.

b. Thrombi of *mechanical or traumatic* origin are those, for instance, which are due to the presence of foreign bodies, to stagnation of blood as the result of ischæmia or local anæmia, to compression by tumors, etc.

c. Infective thrombi are those distinctly due to the injurious effects of micro-organisms, and are those mainly concerned in the various manifestations of sepsis which are of such interest to surgeons. (*Vide* Plate II. Fig. 2.)

While the ordinary evidences of thrombosis are most often looked for in the veins of the extremities, in the lungs, and in the cranial sinuses, it must not be forgotten that thrombosis may occur equally easily in the portal system of vessels; in which case we find the most marked expressions in this system and in the liver. In cases also of pyæmia proceeding from lesions in the rectum or in the bowels we get our first evidences of infection, abscess, etc., in the liver, and not in the lungs, to which point infective thrombi from other sources are promptly carried.

Thrombi, as such, are classified and spoken of as—

A. *Fibrinous thrombi*, composed principally of fibrin with its marked cohesive properties, and attaching themselves firmly to vascular walls.

B. *Hæmatoblastic or globulin thrombi.* By many recent investigators these are supposed to be in some obscure way connected with the activities of the third corpuscular element of the blood.

C. *White or leucocytic thrombi.* These are composed for the most

part of the white corpuscles, which have attached themselves to the surface of the vessel-wall, especially where circumstances favor, as at the point of division of a vessel, or where a sudden curve leads to stagnation of the current. This form is relatively rare; is most common in cases of leucæmia, in which the capillaries of the mucous membrane, especially of the intestines and nose, are filled with them and made to resemble white streaks. They occur also in the rear of certain emboli when the section of the occluded vessel behind them is very short; also behind venous valves, in the spaces between the columns of the heart, and in the sheltered cavities which form in connection with aneurisms and varices. It is said that they also form in slowly-circulating blood as free thrombi.

D. *Red blood-corpuscle or hæmatostatic thrombi.* This is a genuine stagnation form, to which removal of blood-serum from the area involved is a contributing factor. It takes place also when pressure is exercised on the red corpuscles. White corpuscles which are entangled with the red usually lose their identity. The best examples of this form are seen in those regions where a good-sized vascular area is shut off, as, for example, at the ligature of a vein of some size. Under these circumstances the arteries are dilated, and the collateral circulation usually takes away the overflow. All the so-called ischæmic conditions depending upon arterial contraction can cause stagnation thrombi if they occur in a region whose veins are enlarged and well filled. Lessening of venous flow is always accompanied by increase of vascular pressure, and this determines increase of exudation, and usually œdema. Very typical forms are met with in senile gangrene, also after contusions and various injuries. Propagation of such thrombi along the arteries is often noted. Small thrombi also belong here, resulting from venous stasis combined with hemorrhage, and such occur about the constriction in certain cases of strangulated hernia, and lead to the so-called hemorrhagic gangrene. This disaster, however, is by no means the necessary result of these thrombi.

E. *The mixed thrombi, or thrombi in layers.* These layers are formed by deposition at different times of the solid material of the blood, which layers are not necessarily duplicates of one another. Moreover, if considerable intervals of time elapse between layer-formations, the older will have time to undergo marked changes, usually in the direction of condensation and organization. This kind of lamination of thrombi is seen most often in dealing with aneurisms and hæmatomata, concentric deposits having taken place at various intervals.

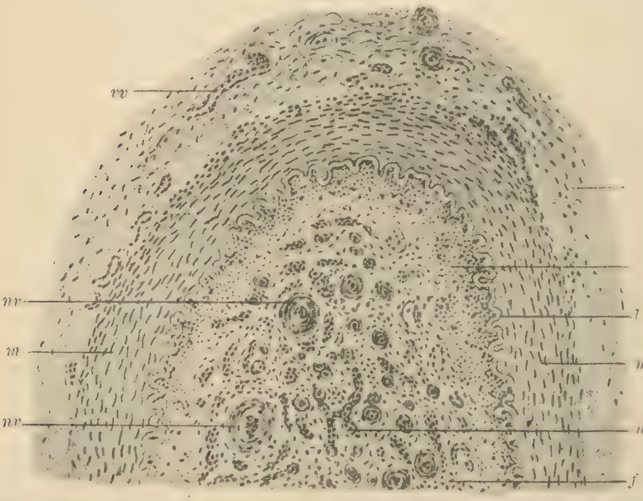
Of all the thrombi met with in the body, the mixed and the white forms are the most common. All of these are to be carefully *distinguished from post-mortem clots.* These latter are moist, glistening, elastic, with smooth surface and showing no evidence of other change. Thrombi, on the contrary, are dryer and more compact, and, if they have attained any age, are more or less laminated or at least stratified. If from a thrombus which has attained some age a piece be torn off, it terminates in an almost stair-like extremity (Cohnheim), due to its stratification.

Thrombi also pass through certain metamorphoses which must be mentioned:

A. *Decolorization.*—This is noted particularly in the red thrombi, and is due to disintegration of the red corpuscles, their coloring matter being diffused and resorbed or transformed into hæmatoidin. It would be a mistake, however, to suppose that all light-colored thrombi are those which, originally red, have been decolorized. The possibility of white thrombi must be always remembered.

B. *Organization.*—This is the result of time, and means a metamorphosis into solid vascular connective tissue. Newly-formed minute vascular loops project from the vasa vasorum into the thrombus, and it becomes thus vascularized, while the completion of the organization is due, for the most part, to spindle-celled connective tissue, which is formed by wandering cells that penetrate into the

Fig. 4.



Organization of thrombus (Letulle): *vv*, vasa vasorum still open: *m*, media rich in muscle-cells; *l*, intima; *f*, fibro-vascular tissue; *nc*, new capillaries; *nv*, new arterioles.

thrombus from without. This gives the organized thrombus a certain resemblance to a sponge, and makes the original vein resemble a cranial sinus, since its interior is spanned by bands of connective tissue. Typical illustrations of this kind are seen, for instance, where the iliac veins join to form the inferior cava, by which a certain amount of obstruction to venous return is produced without its being total. The length of time required for these changes is indefinite. They begin, however, within a short time after ligature of a vein, and proceed with a rapidity varying according to circumstances.

C. *Calcification.*—Calcium salts are occasionally deposited in thrombi, usually not until they have undergone considerable contraction and alteration; as the result of which we have formation of small masses, essentially minute calculi, to which the name of *phleboliths* has been given. These phleboliths are not infrequently found in more or less occluded and much distended varicose veins of the extremities. Their formation is favorable in this regard, that they prohibit the occurrence of softening.

D. *Softening.*—This is the most serious termination of the thrombotic accident, and is, for the most part, due to the agency of infecting organisms. A non-infectious form is, however, recognized, by which there is a metamorphosis of original clot into an oily or pulpy fluid, usually dark colored, but in the white thrombi often yellowish-white, reminding one crudely of pus. The discovery of such material under these circumstances has led in time past to the supposition that pus, as such, was found floating in the blood—a condition that does not exist under any except most extraordinary circumstances. It is with infection of thrombi and consequent softening, however, that surgeons have most to deal, and the paramount importance to them of such disturbances is emphasized in those pages dealing with pyæmia.

A closely-allied topic to that above considered is the subject of **thrombo-phlebitis**. This means, in effect, inflammation of one or more veins, which is directly due to the presence therein of thrombi. Such a condition is, in its strict sense, an inflammation, since it is always an infectious process. If in the veins of a non-infected region simple thrombi form, they may be occluded by organization of the included masses, but such a process never extends beyond the immediate area involved. On the other hand, if the process be essentially an infectious one, either from without or from within, then both vessel and its contained thrombi succumb completely to the infectious process, which is also essentially a spreading one; and this is limited only by mechanical barriers, by conservative suppuration, or often only by the life of the individual. Excellent examples of thrombo-phlebitis are seen in the involved uterine sinuses in cases of puerperal septicæmia, and in the cranial sinuses after infected compound fractures, or particularly after disease originating in the middle ear has extended to them.

Thrombo-phlebitis is essentially a surgical condition, terminating favorably occasionally by suppuration and spontaneous evacuation, but calling loudly for surgical intervention whenever it can be recognized and the parts are accessible. The principles of treatment of these conditions are positive and unmistakable. They comprise evacuation of the infective material and disinfection of the involved cavities and tissues. Thus, in sinus-phlebitis—*i. e.* thrombo-phlebitis of the cavernous sinus—it has been made practicable not only to open the sinus in the mastoid region, but to expose the jugular vein in the neck, to ligate it, and to wash through from one opening to the other, effectually getting rid in this way of a long mass of infected thrombus. By such bold and radical measures only may life be saved in many of these instances.

Embolism.

Embolism means the *transportation of any material by which a blood-vessel can be occluded or plugged* from some one point in the vascular system to some other point. The underlying idea is that of *transportation* or carriage. An *embolus* is anything so transported, without implying its exact character. The name is even applied to so insubstantial an affair as a minute bubble of air, which, however,

in a tube containing a circulating fluid is a possible source of considerable disturbance. A single bubble thus carried would, by itself, be a trifling affair, but when numerous bubbles are thus transported the result is such local disturbance as may lead to loss of function. Thus, *air-embolism*, so called, may provoke profound, even fatal, disturbances, as, when with the returning blood-stream through the cranial sinuses or one of the large veins in the neck when opened by accident or operation, air is sucked in, it is carried to the right side of the heart, whose action is perhaps completely perverted because of the new and strange substance which thus enters it, so different from that for which its lining membrane is prepared and to which it reacts. The *entrance of air into veins*, which constitutes in effect air-embolism, has been in time past a bugbear to surgeons, but nevertheless is a source of probable danger when large venous trunks in proximity to the heart are thus exposed. Air-embolism is certainly a rarity. On the other hand, those substances which figure most often as emboli are *vegetations from the valves of the heart; drops of fat; fragments of tumors; pieces of softened and disintegrated thrombi; foreign bodies*, as hooklets of echinococcus cysts; and, perhaps most often of all, the *micro-organisms* clinging to some minute fragment of thrombus which has been dislodged. Embolism is also produced experimentally by the artificial introduction into the circulating blood of cinnabar or small particles of pith or other material. Emboli differ in size, from the smallest appreciable up to the largest, which may be met with in the larger venous trunks. They are *dislodged* from their primary site sometimes by *accident*, as by rude manipulation, injury, etc.; sometimes by *undue cardiac activity*, as when detached from a valve-wall; sometimes by the *process of softening* of thrombus and a subsequent introduction into the blood-stream as a result of some trifling motion; or even by *spontaneous processes*. Emboli also differ in numbers according to the nature of the primary lesion. In cases of so-called fat-embolism fluidified fat is taken into the returning blood-stream, carried to the heart, churned up with the contained blood, and distributed to the lungs in such a way that myriads of minute fat-masses are distributed throughout the capillaries of the lungs, and free circulation of blood through them thereby impeded.

Whatever may be the character of the embolus in a given case, given its origin, its direction and course can be predicated up to at least a certain point. The embolus which springs from the left side of the heart will always be swept into the aorta, but, so far as known, it is accident alone which determines whether it shall be diverted into one of the main arterial trunks which spring from the aortic arch, or whether it shall be carried down to be sent out through one of the lower aortic branches. On the other hand, the embolus which is produced as the result of a thrombus in the portal system is surely first lodged in the liver, while that coming from any one of the general systemic veins is first carried to the right side of the heart, and then to some branch of the pulmonary artery, and embolism of the lung is the consequence. Whether, now, from the lung there shall emanate further disturbance of the same character will depend upon the source and nature of the embolus in question. If it have come from an infected thrombus, it will be sure to set up within the lung disturbance similar to that where it originated; the consequence of which will be coagulation-necrosis and thrombosis in the area involved, with repetition of the original condition and likelihood of repetition of the original accident. Let, now, a thrombus come from this secondary focus in the lung: it returns with

blood by the pulmonary vein to the left side of the heart, whence it may be distributed to any point in the entire arterial system, this point, again, being determined apparently by accident. Septic thrombi, if they occur at all, are practically multiple and usually exceedingly numerous; and so, if the embolism partake of this septic character, we may be sure that a crop of septic emboli has been distributed, rather than one embolus. In each instance, however, there will again be a repetition of the original condition; and it is by these means that so-called metastatic foci, either of cancer or of septic infection, are produced. The term *metastasis*, therefore, is indistinguishable from a consideration of embolism, and its fundamental significance in surgical terminology is that of *transportation of some injurious material*. It will be readily appreciated that after entrance into the arterial current a given embolus will be checked only when it has entered an artery whose lumen is too small to permit its passage without greater pressure than that at the time existing in the blood-vessel.

It will thus be seen that the relations between thrombosis and embolism are most intimate, but that either one may occur without the occurrence of the other.

As the *result of the combined or single condition* we may have—

1. *Temporary occlusive effects*, which are later atoned for by the collateral circulation. This is possible in any given case, except when the artery involved is one of those known as terminal. In this instance the condition of the parts supplied by said vessels is hopelessly compromised. The best examples of this are seen probably in the brain, where the arrangement of vessels is peculiar, and where an area which is thus shut off remains condemned to a minimum of blood-supply which shall be insufficient for perfection of function, and often so slight as to be followed by degeneration, etc. In other words, the question always is whether there is beyond the plug and between it and the capillaries a sufficient arterial anastomosis with the obstructed vessel. If not, aside from the enforced anæmia of the affected region, the occluded vessel becomes filled with thrombus, while, if the individual live long enough, there will arise in advance of it either uncomplicated necrosis or a necrosis associated with engorgement, leading to that described below as hemorrhagic infarction.

2. *Infarct*, which refers to the area of tissue, usually conical in outline, representing so much as is shut off from blood-supply by the occlusion of the artery supplying that region. In this case the apex of the cone corresponds to the location of the embolus, the base of the same to the surface supplied by the terminal ramifications of the obstructed vessel. Infarcts are divided into the *anæmic*—which is practically the condition already described—and the *hemorrhagic*, which is the usual sequel of coagulation-necrosis in front of the arterial plug. Such infarcts are often visible to the naked eye, and occasionally involve areas of considerable size. The so-called hemorrhagic character is given to them by the reflux of blood which takes place from the contiguous capillaries or arterioles, insufficient for continuance of function, but with sufficient *vis a tergo* to escape from vessel-walls already weakened by coagulation-necrosis, and to constitute in effect a truly hemorrhagic lesion. The most pronouncedly hemorrhagic infarcts are met with in the lungs. In lesser degree they are seen in the spleen and kidneys, though most of the infarcts met with here are of the anæmic variety.

Coagulation-necrosis is, however, not the most serious sequel to infarct; but when embolism involves the popliteal artery, for instance, it may be followed by gangrene of the foot and leg. Gangrene of the lung or of other tissues may also occur even if the original embolus be not septic, since large areas thus shut off receive a blood-supply insufficient for the barest needs of nourishment, and, tissue-resistance thus lowered, infection becomes easy, so that moist, septic gangrene may be the result of an original non-septic lesion.

Embolism, then, is ordinarily a most undesirable condition. Yet in rare instances we take advantage of its possibilities and endeavor deliberately to provoke it, practically for the same purposes that we endeavor to provoke thrombosis—*i. e.* for the cure of aneurism mainly.

Inasmuch as an aneurism is always lined by laminated thrombi, it has been suggested to cause the detachment of some particle of this material by forcible manipulation, hoping that it will thus form an embolus as it is swept into the blood-stream, and that it may plug the vessel below in such a way as to produce the same effect as would a ligature applied from without. Although the method is so simple in theory, and though surgeons have availed themselves of it in the past, it is essentially unscientific and clumsy, mainly for the reason that the consequences of such manipulation cannot be controlled, and more harm than good may be done, even to the extent of producing gangrene or of rupturing the sac.

Among the viscera, with the exception possibly of the brain, nowhere are the disastrous consequences of such processes as those just described more apparent and indicative than in *thrombosis and embolism of the mesenteric blood-vessels*—a condition not so rare as journal articles would imply, yet nevertheless one seldom recognized either during life or after death. Its principal symptoms consist of intense abdominal pain, bloody diarrhœa, subnormal temperature, sometimes with vomiting, perhaps in the latter stages vomiting of blood. Shock is usually also extremely marked. The consequence of this condition is almost inevitably gangrene of the intestine supplied by that particular portion of the mesenteric vessels. The pain comes on within a short time after the occurrence, and under the peculiar circumstances gangrene may be practically determined within fifteen hours. More than fifty cases of this kind are now on record in surgical literature, and the condition is one well worthy the prompt attention of the surgeon, because only by surgical intervention—*i. e.* by resection of the necrotic mass of intestine—can life possibly be saved. Thus, Elliot[1] successfully resected $1\frac{1}{4}$ metres of intestine for this purpose.

Fat-embolism.

Fat-embolism as a distinct, sometimes fatal, surgical condition has received of late so much study as to be now entitled to consideration by itself. By this term is meant a plugging of small arteries by minute drops of fat, which, having been set free somewhere about the periphery, are carried into the venous circulation and thence distributed to various parts of the system. Inasmuch as the capillaries of the lungs are often the first lodging-place, fat-embolism here is most often met with, and consequently recognized and studied. But

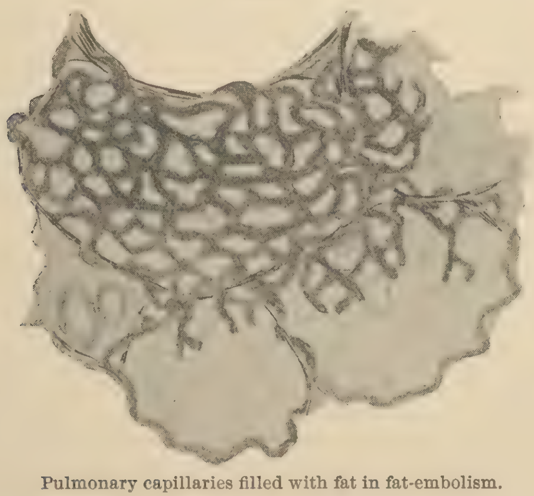
[1] *Annals of Surgery*, Jan., 1895, p. 9.

it may obtain in the brain, the choroid, the kidneys, or other parts, provided only that there has been sufficient *vis a tergo* on the part of the heart to force the fat-globules through the pulmonary capillaries and into the systemic circulation.

Fat-embolism occurs relatively quite often, and to a slight extent in nearly every case of fracture and laceration. So common is it, and so closely allied are some of its most prominent symptoms to those of shock, that as a matter of fact many cases heretofore considered shock are really to be regarded as instances of this condition. Indeed, even in a miscellaneous series of 260 dead bodies fat-embolism was found in 10 per cent. The injuries most likely to be followed by it are simple, and particularly compound fractures of bones; laceration of soft parts, especially of adipose tissues; certain surgical operations; acute infections of bone and periosteum; rupture of fatty liver; and certain pathological conditions where the phenomena are not so easily explained—*e. g.* icterus gravis, diabetes, etc.

Drops of fat may be seen floating on fluid or semi-fluid blood after many operations and compound injuries, and the possibility of escape of fat—or, more accurately, its suction into the vessels from which this blood has escaped —is easily appreciable. But it has also been shown that absorption of fat is possible even from serous surfaces, and that fat-embolism may occur when fluid fat has been passed into the heart through the thoracic duct, although more slowly. Oil-drops are also found in the interior of the tissues, while in a piece of lung spread out in water in the visible vessels highly refracting fatty material may be noted. *Fatty infarction*, particularly in the lower lobes, is sometimes plainly visible to the naked eye. Under a low objective, especially with osmic-acid staining, the presence of fat is easily and beautifully demonstrated.

Fig. 5.



Pulmonary capillaries filled with fat in fat-embolism.

The essential danger in case of fat-embolism is of so clogging the pulmonary capillaries that oxygenation shall become so imperfect as to lead to absolute asphyxiation from carbonic-dioxide poisoning. When this fact is understood, the cyanosis, the rapid breathing, the over-action of the heart, etc. are easily and correctly interpreted.

Fat-embolism by itself cannot cause inflammation nor infection nor sepsis in any sense. It may, however, lead to ecchymoses in conjunction with fatty infarcts in the organs most affected. The minute hemorrhages are easily explained by bursting of the capillaries in the attempt to force blood through them. Fatty emboli, however, take the same course as do septic—are carried first to the right side of the heart and distributed over the lungs; are, if the patient live, forced through the lungs into the systemic circulation, and are then carried to the brain, kidneys, etc. The first symptoms are referable to the plugging of the pulmonary capillaries; the secondary symptoms to the systemic disturbance.

Symptoms.—Pallor of countenance with facial expression of anxiety and distress, followed by cyanosis and contracted pupils, are seen. Patients are usually first excited, sometimes more or less disturbed, then become somnolent, and, finally, comatose in the fatal cases. The respiration-rate increases from normal up to 50 or 60, and breathing is sometimes stertorous. Dyspnœa, increasing in intensity until it becomes agonizing, sometimes marks these cases. Occasionally foam, possibly blood, proceeds from the mouth, as in œdema of the lungs. Occasionally, too, hæmoptysis occurs. The pulse becomes weak, frequent and irregular, while toward the close it is fluttering. Temperature is not notably disturbed, at least not typically.

These symptoms set in usually within thirty-six to seventy-two hours after the lesion which has caused them. I have, however, known death to occur in one or more cases within eighteen hours after reception of injury.

After fat has been forced through the lungs and carried to the kidneys it will be eliminated with the urine, and may be found floating upon it in the shape of oil-like drops. Discovery of this condition is positive evidence of fat-embolism. It is to be distinguished from shock in that by the time the symptoms of embolic disturbance are at their height, all or nearly all symptoms of pure shock should have subsided. Furthermore, cyanosis and embarrassment of respiration are not indicative of shock; and, finally, the discovery of fat in the urine will be corroborative.

A mild degree of fat-embolism may be noted, if looked for, after almost all serious fractures. It will give rise to slight embarrassment of respiration and cyanosis and to the elimination of fat by the kidneys.

Prognosis.—Prognosis is somewhat in proportion to the extent of the injury and the proximity of the lesion to the heart and lungs; also to the possibility of continuous entrance of fat—*i. e.* from its continual absorption. Prognosis really depends upon whether the heart can be given sufficient vigor and endurance to continue pumping blood with its burden of fat through the pulmonary circulation. A secondary danger may come from the circulation of this fat-ladened blood through the capillaries of the brain. Should the source of motive power thus become paralyzed along with general enfeeblement, death may ensue. When well-marked evidences of fat-embolism are present, but are followed by recovery, the worst of the trouble is usually over within forty-eight hours after it begins.

Treatment.—Obviously, treatment is mainly directed toward the

heart that it may stimulate it to carry its load of fat through from the venous into the arterial system. If it can do this, the fat is disposed of by oxidation or is saponified by the alkalies in the blood. Physiological rest of the injured part is the first indication, however, and if this occur in a patient, say with delirium tremens, powerful mechanical restraint may be necessary. The most powerful cardiac stimulants are called for—alcohol, digitalis, strychnia. In other respects treatment is largely symptomatic. Next to giving the heart vigor in this way, inhalations of oxygen give the most promise, because of the crying need of the system during this ordeal for this life-giving gas.[1]

The Corpuscular Elements of the Blood.

Within the past few years has come into a considerable importance the so-called *third corpuscle* or *blood-plaque*, minutely described by Osler and others. It is composed of colorless protoplasm, averaging $2\frac{1}{2}$ μ (mikrons) in diameter, and is present in proportion of about one to twenty of the red blood-corpuscles. While circulating in the blood these plaques do not ordinarily cohere, but immediately on their withdrawal they form aggregations; to which fact is due the lack of their earlier recognition. They are most numerous in the infant and in the aged. Their presence is not yet fully accounted for, and their relation to the formation of other corpuscles not yet distinctly determined. In acute infectious diseases and in certain chronic wasting forms they exceed their normal proportion. During crises of fevers and during convalescence from acute and extensive suppuration they are most often seen in large numbers.

The blood-plaques are not the only corpuscles of the blood which undergo rapid increase or diminution in number, since this is true also of the leucocytes, which during acute inflammations rapidly augment in number. Whether this is to furnish more which may escape from the blood-vessels and act as phagocytes, or whether destined to some other purpose, is not yet settled, though the former is probable. Under many of the circumstances connected with phlegmon and active corpuscular escape it is found that the spleen and lymph-nodes are materially enlarged. Temporary increase in the proportion of leucocytes is known as **leucocytosis**, which is a usual accompaniment of suppuration, even though the focus of activity be small. Diminution in number of white cells is known as **oligocythæmia**, and its significance will be alluded to below. The relation of the leucocytes, which contain most of the paraglobulin and peculiar ferment which are such important factors in the coagulation of blood, to thrombosis is most important; and it must naturally follow that breaking-down of these cells—*i. e.* release of such materials—will have very much to do with coagulation, and that, therefore, thrombosis may be a frequent accompaniment of leucocytosis in inflammation. The colorless corpuscles contained in the blood and lymph present several varieties more or less distinct from each other, and are classified as follows:

Lymphocytes.—Small leucocytes with large, round nuclei and a relatively small amount of protoplasm, occurring conspicuously in the

[1] See paper by the writer, *N. Y. Med. Journ.*, Aug. 16, 1884.

lymph-nodes. They stain readily, especially with aniline dyes, which color the nucleus deeply and the protoplasm faintly. These lymphocytes grow until they become large-sized leucocytes, and it is characteristic that the larger they grow the more easily their protoplasm stains and the less so their nucleus. As they attain larger size their nuclei sometimes change in shape, and it is not always easy to distinguish a large mononuclear leucocyte from certain fixed connective-tissue cells or endothelial cells.

The **eosinophile leucocytes** contain in their protoplasm granules which do not stain with basic aniline dyes, like fuchsin, methyl violet, etc., but which readily take up the acid aniline colors, especially eosin; whence their name. In this variety the nucleus is variable in shape and form, and is often lobed.

Another form is represented by cells in which the nucleus is either lobed or composed of portions united by delicate filaments, giving the impression of a multinuclear cell—in fact, the nuclei often are really multiple. Hence this form is known as the **polynuclear** form. These leucocytes also contain a small central body of chromatin and polar filaments of achromatin. Their nuclei are deeply stained by aniline dyes, while their protoplasm remains for the most part unaffected. This latter is granular, and can only be stained by a mixture of acid and basic dyes, so that these polynuclear forms are often spoken of as *neutrophile.* This form comprises about three-fourths of the total number of leucocytes in the blood. The term formerly used, *myelocyte—i. e.* a cell supposed to be found in the bone-marrow and distinct from the other leucocytes—has been nearly abandoned. Ehrlich, who has been the leader in this study of blood-cells, has shown that the eosinophile cells form in the blood at the expense of smaller ones which have been produced in various organs. Consequently, an undue proportion of eosinophile cells indicates pathological activity of bone-marrow and betokens one form of leucocythæmia.

The entire modern study of leucocytes of the blood is based upon their reaction to certain staining agents, for the most part the aniline dyes. According to these reactions in connection with peculiarities of size, shape, etc., we speak, then, to-day of the following varieties of white corpuscles:

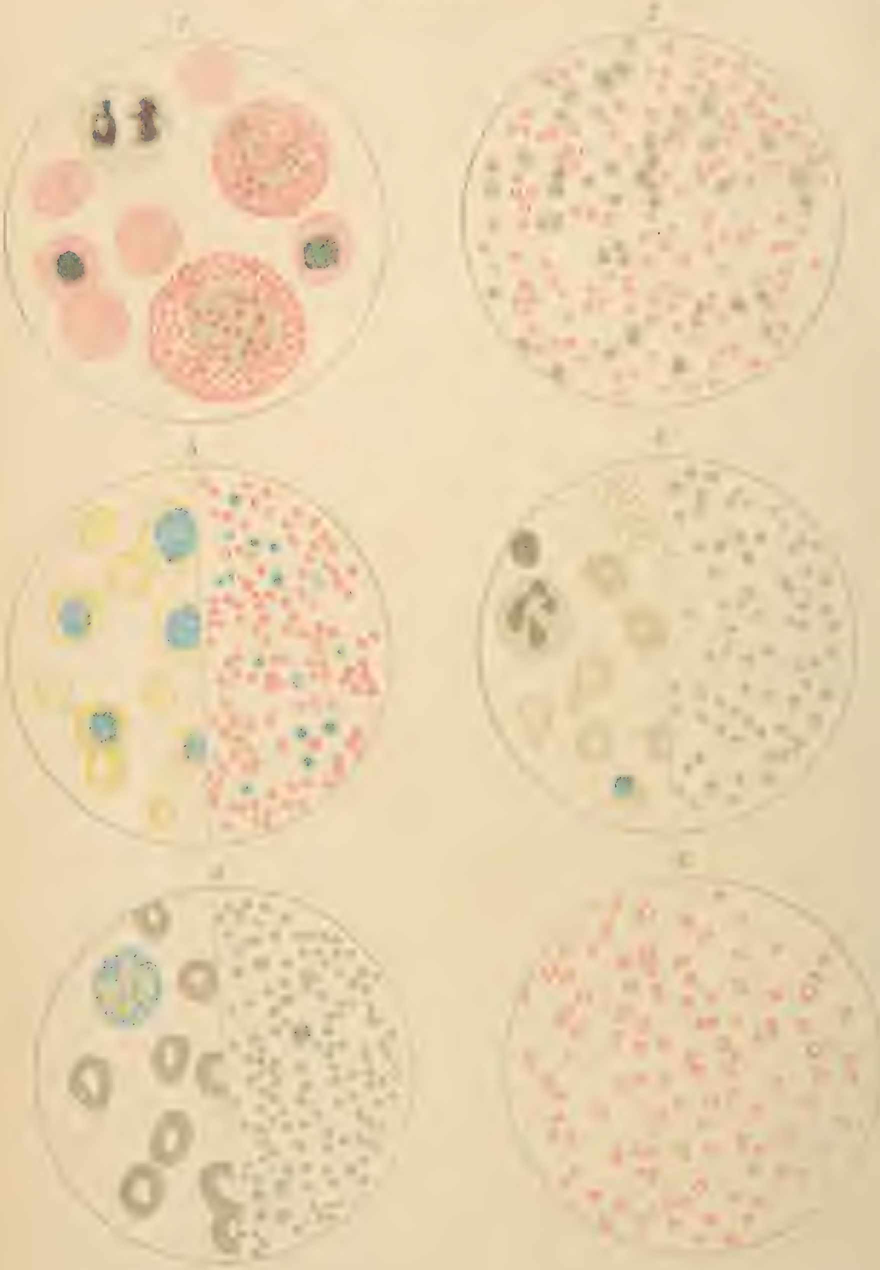
1. *Lymphocytes*, derived from lymphoid tissues of the body; in number from 20 to 30 per cent. in the leucocytes of the blood. Their nucleus is large, and their non-granular protoplasm appears only as a narrow rim.

2. *Large mononuclear forms*, with large, oval, feebly-staining nuclei and a fair quantity of non-granular protoplasm; 2 to 3 per cent.

3. *So-called polynuclear leucocytes*, those with polymorphous nuclei. These represent two-thirds of the whole number of leucocytes. They are smaller than No. 2, and have irregular nuclei. Their protoplasm contains numerous neutrophilic granules, and they are often called polynuclear neutrophiles.

4. *Transitional forms*, similar to No. 2, with irregular nuclei, in transitional stage from mono- to polynuclear form, constituting about 3 per cent. of the entire number.

PLATE I.



Appearances of the Blood Corpuscles in Various Conditi

PLATE I.

Appearances of the Blood Corpuscles in Various Conditions. (Rieder.)

1. **Mixed Leucæmia or Myelæmia.** Four red corpuscles without and two with nuclei; two large eosinophile (marrow) cells; one leucocyte, showing mitotic division of its nucleus. x 1600. Eosin-hæmatoxylin.

2. **Acute Leucæmia.** Leucocytes mostly mononuclear, small; reds regular in outline. x 300. Eosin-hæmatoxylin.

3. **Lymphatic Leucæmia.** On the right, x 300. Red corpuscles rosy pink, mono- and polynuclear white corpuscles blue. On the left, x 1100; red corpuscles neutral tint, white corpuscles blue. Eosin and hæmatoxylin stains.

4. **Anæmia Gravis with Leukocytosis.** On the right, x 300. Red corpuscles very pale; leucocytes polynuclear. On the left, x 1100. Reds irregular in outline; one large polynuclear leucocyte, one small mononuclear; mass of blood-plaques. (From case of carcinoma) Eosin-hæmatoxylin.

5. **Inflammatory Leukocytosis.** On the right, x 300. Polynuclear leucocytes (neutrophile) greenish blue. On the left, x 1100. Same, showing nuclei among numerous granules contained within the cell. (From case of croupous pneumonia) Aronson's stain.

6. **Anæmia Gravis.** Poikilocytosis of reds, with macro- and microcytes; one mononuclear leucocyte with blue-stained nucleus. x 300. Eosin-methyl blue.

5. *Eosinophile cells*, same size as No. 3; nuclei variable, protoplasm largely made up of refractive eosinophile granules. They constitute from 2 to 4 per cent. of the total of leucocytes, and originate in bone-marrow. Nos. 2, 3, and 4 are regarded as formed in both spleen and bone-marrow.

These proportions are fairly constant in a state of health; in the presence of certain diseases they vary widely. *Hence the value of proper estimation and recognition of their relative proportion.* It is also generally accepted that in certain diseases cells not met with in health may be found in the blood. These have not yet been sufficiently studied, but their recognition is a matter of growing importance. Their various appearances are indicated in Plate I.

Leucocytosis as an Element in Diagnosis.—*Leucocytosis* differs from *leucæmia* in that while both refer to the increase of the actual number of white corpuscles in a given volume of blood, and while in both instances these belong to the classes found normally present, in the former instance the condition is a temporary and evanescent one, while in the latter it is a permanent one and constitutes a marked feature of the disease. It is perhaps incorrect to say that in leucæmia only the normal types of cells are present. All of the normals are present, but there are also present those which are not found under normal conditions. In *leucocytosis the increase is mainly in the polynuclear cells.*

The normal standard implies that in a cubic millimetre of blood there should be present about 7,500 leucocytes to from 5,000,000 to 5,500,000 red blood-cells; but the relative proportion of whites varies even from hour to hour within certain limits, and a relative leucocytosis is normal during digestion of a hearty meal, during pregnancy, and in newly-born children. But, as an index of abnormal conditions, one may say in a general way that leucocytosis as a diseased condition is nearly always associated with the inflammatory process, with certain malignant tumors, and in other rare conditions which may be mentioned below. Any variation of more than 1,500 above or below the above standard of 7,500 should be considered abnormal.

Some writers have stated that leucocytosis exists during typhoid fever. This is, however, distinctly a mistake, since it is never present except when some such complication as thrombosis, abscess, pneumonia, etc. complicates the case. It is even possible to make a diagnosis as between relapse and other complication by counting the leucocytes. This is particularly *true in cases of appendicitis*, since it is difficult sometimes to diagnose as between typhoid and appendical disease. Should leucocytosis be present, diagnosis may be positively made in favor of the latter. So, also, in general septic conditions, which may be differentiated from typhoid in the same fashion. Again, in case of threatening surgical complications, so long as the leucocytes are normal in number one may pin his faith to typhoid alone.

It is not so, however, in pneumonia. In this disease there is a marked increase in the white corpuscles. Moreover, prognosis is bad in pneumonia when this condition does not obtain, as Cabot has shown. In cases of acute obstruction of the bowel, so long as no leucocytosis is present the case is not one of appendicitis nor of suppurative peritonitis.

In malignant disease, especially in the soft and rapidly-growing tumors, and particularly in sarcoma of bone, there is marked leucocy-

tosis, by which in doubtful cases a distinction may be made before operation between malignant conditions and tuberculosis, chronic arthritis, etc. It is furthermore stated that in malignant disease, even when no leucocytosis is present, a differential count of stained specimens will show marked increase in the percentage of polynuclear cells. In all forms of suppuration, deep or superficial, circumscribed or diffuse, and in all types of septic invasion and infection, leucocytosis is present. Cabot has shown how the test may be applied in cases of deep wounds, compound fractures, etc., where one is disturbed by rise of temperature, etc. and hesitates whether or not to re-dress the wound. If there be no leucocytosis present, there need be no fear of retained or accumulating pus.[1] Furthermore, in such a case—for instance, as one of uncertain diagnosis between typhoid and purulent meningitis—an increase of leucocytes will point surely to the latter; and diagnosis has been corroborated by the discovery of middle-ear disease, from which the meningeal complications proceeded.

It will be seen, then, that the relative and numerical estimate of the richness of the blood in its white corpuscular elements may be of the greatest service to the surgeon by furnishing indications of importance for the subsequent management of the case or for diagnosis.

Red Corpuscles.—With care in examination certain differences can be detected in the behavior and size of the red corpuscles, which may also furnish important information. This brings up mainly in this connection the question of the anæmias, which are *relative* and *positive*. After an acute loss of blood, as after operation or accident, there is, of course, a deficiency in the amount of blood in the system, which, however, does not materially influence the proportion of reds to whites nor the number of reds present in a given volume. *Oligocythæmia* is a term applied to a deficiency of red corpuscles, or to a condition by which their relative proportion is recognizably lowered. If we accept from five to five and a half million of red cells in a cubic millimetre as the normal standard, it will be seen that we may have various degrees of oligocythæmia, which, however, is rarely reduced below a proportion of two million. *Poikilocytosis* is a term applied to that condition in which the red corpuscles are irregular in shape and in size, these irregularities varying from the slightest crenation of their borders up to a very marked alteration in all their proportions.

It is possible, then, without long special training, to estimate both the number of the red cells present, their thickness, shape, general appearance, whether they are very biconcave or not, and how they react to ordinary stains; from all of which considerable valuable information, sometimes of the greatest importance, can be gained. Stains particularly readily illustrate alterations in shape and nucleation. In all acute anæmias and in many of the chronic and secondary forms nucleated corpuscles may be determined: the nuclei have peculiar refraction, and perhaps are even seen in the act of escaping from their parent corpuscles. In certain grave forms of anaemia, particularly in the per-

[1] *Boston Med. and Surg. Journ.*, March 22, 1894.

nicious form, and in the leucæmias, one finds corpuscles larger than usual with pale-staining nuclei, in which a network of karyokinetic figures can often be made out. This has led to the fanciful distinction between *normoblasts*—*i. e.* red corpuscles of normal tissue—and *megaloblasts*, meaning thereby the form just described.

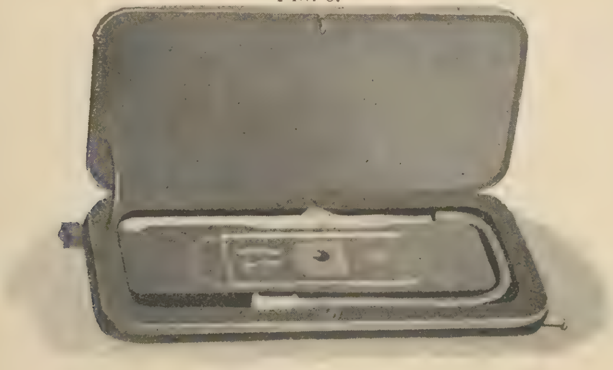
Inasmuch as I have spoken of the source of the various forms of leucocytes, I should state here that it is now generally held that the red corpuscles are formed almost solely from the nucleated red cells which may be seen in the red marrow of bone, the transformation taking place by the process of extrusion of the nucleus. Inasmuch as the nucleated cells increase in bone-marrow very rapidly after great loss of blood, this view is in large degree corroborated thereby. The marrow-cells divide also by mitosis in order to produce the red blood-cells. It will thus be seen that bone-marrow is most important in the formation both of the red and the white corpuscles, and that to it we must look for the source of most of them, rather than to the spleen, in which, after all, little if any such activity can be proven. How rapid may be regeneration after hemorrhage, etc. is shown by their manufacture at the rate of over fifty thousand per cubic millimetre a day (Osler).

Methods of Examination.

These can be referred to here only in the briefest possible manner. The student who desires to take up this matter carefully should refer to works on physical diagnosis, such as those of Von Jaksch, etc.

The principal examinations called for in pursuing the methods of diagnosis above outlined are the *estimation of the red corpuscles*, the *numerical and differential estimation of the leucocytes*, and the *estimation of hæmoglobin.* The apparatus

Fig. 6.



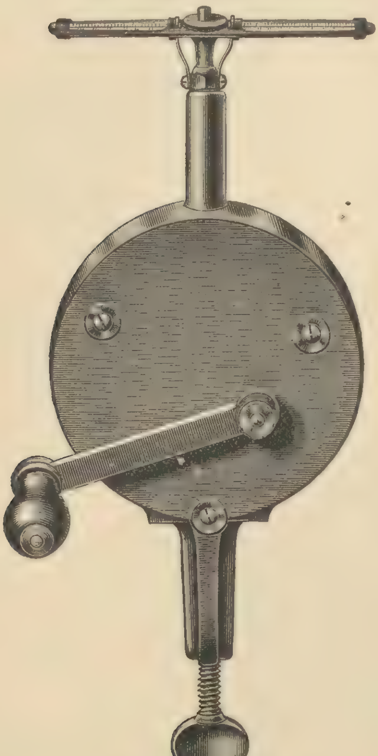
Thoma's hæmocytometer.

generally in use for counting the red corpuscles is that of Thoma, made by Zeiss, in which the blood is diluted in a mixer from one to two hundred times, a saline fluid being used whose specific gravity corresponds with that of the blood. It is an advantage to slightly tinge this with methyl violet, because the leucocytes take up this stain and are as easy to count as are the reds. Using this instrument, the error will probably not exceed 2 to 3 per cent.

A very convenient and for many purposes sufficiently accurate method of estimating the solids of the blood is by *centrifugating machines* or *hæmatokrites.* For this purpose the blood is mixed with an equal volume of Müller's fluid or of a $2\frac{1}{2}$ per cent. solution of potassium bichromate, with which the capillary tube is filled; after centrifugation for several minutes the red blood-corpuscles will be found to have separated themselves to the farther end of the tube, since their specific gravity is greater than that of the whites. Their relative propor-

tion may be read off upon a graduated scale. The same may be done with the whites. In the average of healthy individuals the red blood-corpuscles will occupy about one-half of the length of the full tube. This corresponds to a little over 5,000,000 corpuscles to the cubic millimetre. About one-fiftieth of the length of the tube will be occupied by the white corpuscles, whereas in advanced cases of leucæmia the leucocytes may occupy ten or twelve times as much space. This method of centrifugation certainly offers an easy and for many purposes a sufficiently accurate estimation. By making repeated examinations in the same case it affords a very accurate method of judging of progress or the reverse. Daland's admirable instrument is shown in Fig. 7.

Fig. 7.



Daland's hæmatokrit.

Upper view of Daland's instrument.

Up to the present it has been found of no practical value to count the number of blood-plaques or third corpuscles present, these varying within wide limits—according to Osler, from 200,000 to 500,000 to the cubic millimetre.

The *leucocytes may be counted* at the same time as the reds, and practically always should be. By this means their relative proportion to each other is determined, and the general fact of leucocytosis or leucæmia must be established. But this is now not enough for accurate diagnosis, and we must resort to dried specimens of the blood, stained with various aniline dyes, before a complete estimation can be arrived at. In securing a drop of blood for examination it is best taken from the lobe of the ear, which should be thoroughly washed, pricked, and the minute drop of blood collected upon a cover-glass which has been cleansed and prepared with minute care. These cover-glasses are then kept for an hour or two at a temperature of 120° C., in order that the hæmoglobin of the red cells may be so fixed as not to be removed by the staining fluid. Various stains may be used, the aniline dyes being largely resorted to for this purpose. The cells are differentiated largely by their reaction or behavior with the two groups of aniline colors known as acid or basic, the former being those in which the staining agent is the acid portion; the latter, those in which it is the basic portion of the combination that forms the dye, while the union of a staining acid and a staining base makes what is known as a neutral dye. Not to go into the refinements of the subject too far, we will simply mention that the triple stain of Ehrlich, containing methyl green, acid fuchsin, and orange G., is the most serviceable for all-round purposes, since by its use the nuclei of the white cells are stained green, those of the nucleated red cells nearly black, the red corpuscles orange, the eosinophilic granules red, and the neutrophilic granules dark violet. I have already called attention to the significance of a preponderance of one of these forms over the other. Let it suffice, then, to say that this is a serviceable method of determining such preponderance.

The amount of *hæmoglobin* is easily determined, either by arbitrary color scales or by the spectroscopic test, and gives information of considerable value

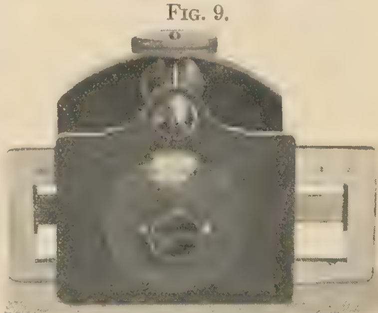
both in diagnosis and prognosis. For its estimation Fleischl's instrument is now generally resorted to. This consists of a wedge of glass of the same tint

FIG. 8.

Fleischl's hæmometer.

as hæmoglobin, which is moved under a cell containing a watery solution of the blood until the tints correspond, when the amount of hæmoglobin present is read off on a scale. Inasmuch as the normal amount in healthy blood is 14 per cent., the number *100* on this scale corresponds to this limit. It is a purely arbitrary method, but one which is very easy of execution, and which gives results sufficiently accurate and indicative to make it of great value. Fleischl's instrument (Figs. 8 and 9) is the one in general use for this purpose.

FIG. 9.



Fleischl's hæmometer, seen from above.

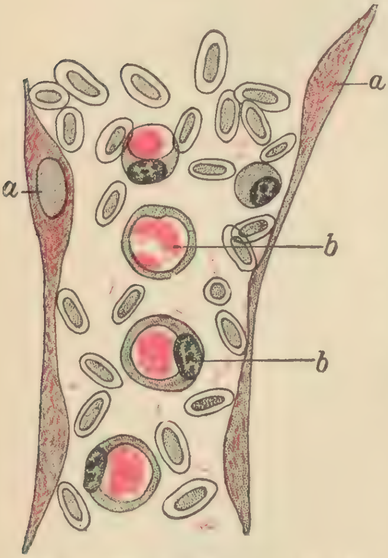
Finally, the *specific gravity* of the blood may be determined by different methods, a very simple one being to have at hand a mixture of chloroform and benzole of known specific gravity, into which the blood is dropped, while enough of one or the other is added until the blood-clot manifests no tendency to rise or fall. The specific gravity of this mixture is now taken, and equals, of course, that of the blood.

PHYSICAL PROPERTIES OF THE LEUCOCYTES.

Phagocytosis.—All leucocytes have the power of shifting their location. The lymphocytes, so called, being the youngest of the white corpuscles, show it less than do even the older forms. Also the eosinophile cells are less able to manifest the peculiar activities of the other forms. It is particularly the mono- and polynuclear corpuscles which are endowed with most pronounced activity. These have the power, like the amœbæ among the lowest forms of life, to not only spread themselves around inert bodies, like granules of carmine or other particles used for experiment, or the particles of coal-dust found in certain conditions in the human body, but they have also the power to englobe many living organisms, for the most part

vegetable (bacteria). Under the microscope it is possible to see living bacilli performing active movements although enclosed in the nutritive vacuoles of the leucocytes in some of the lower animals. This *amœboid* power possessed by these cells of thus attacking and disposing of foreign bodies or irritants has been demonstrated and proven, especially by Metchnikoff, and has been called by him **phagocytosis.** His views were for a long time disputed, and are perhaps not yet absolutely and generally accepted. Nevertheless, they fulfil every demand made upon them for explanation, and are susceptible of such demonstration under the microscope that we now have practically a new and apparently a correct theory of the inflammatory process. (See next chapter.) Any cell which has this property is known as a *phagocyte.* It is shared by certain of the leucocytes with certain other cells to be spoken of later (wandering tissue-cells). Cells which possess this power do not attract all microbes indiscriminately, and it is often the case that the leucocytes of an animal peculiarly susceptible to a certain kind of bacteria do not attract them at all, even though they be directly in contact. It is plausible that an explanation of the peculiar susceptibility of certain animals to certain diseases is furnished by this fact. (See Fig. 10.)

FIG. 10.



Active phagocytosis. Endothelial cells enclosing the bacilli of swine septicæmia, from an hepatic vein of a pigeon: *a*, endothelial cells; *b*, leucocytes (Metchnikoff).

On the other hand, leucocytes may and do englobe virulent microbes. In man the mononuclear forms do not take up either the streptococcus of erysipelas or the gonococcus; whereas these two organisms are readily attracted by the polynuclear neutrophile cells. The bacillus of leprosy, on the other hand, is never attacked by the polynuclear forms, but is speedily devoured by the mononuclear cells. This shows that the various leucocytes may exercise a marked selective ability. This inclusion of minute bodies within amœboid cells seems to be an evidence of a peculiar tactile sensibility upon the part of the latter. In fact, this is clearly established, and seems to be inseparable from the peculiar attraction between leucocyte and bacterium to which the name **chemotaxis** has been given, and which is described in the ensuing chapter. If the included organism be, as is usually the case, killed, it is disposed of by a true process of intracellular digestion in a neutral or alkaline protoplasmic medium, and its inert portions are again extruded. On the other hand, if the leucocyte be poisoned or die in this phagocytic attempt, it presents usually as a so-called *pus*-cell or *corpuscle*, and the solid part of pus is made

up in large measure of cells which have perished in this way. (See next chapter.)

To regard phagocytosis as an affair mostly of certain tissue-cells and invading bacteria would be altogether too narrow a view to take of it. It is really a process of the greatest importance and of constant performance in our systems. By virtue of it disintegrated muscle-fibres and other tissue-cells are disposed of, sloughs are separated, certain absorbable foreign bodies (catgut, etc.) taken away—*i. e.* absorbed—cellular tissue reduced in numerical strength (progressive atrophy); and a great variety of changes, either normal, as those pertaining to health and advancing years, or abnormal, like those incident to many diseases, are actually the product of this kind of phagocytic activity. The protective power, then, which the phagocytes exert as against bacteria is only one part of their normal functions, by virtue of which they become, in effect, perhaps the most important cells within our bodies. Their powers are limited, however, as will be seen when describing pus, for the so-called pus-corpuscle is nothing but a phagocyte which has perished in its self-assumed task. It is known also that in certain instances phagocytes, which are incapable of defence as against the mature bacterial organism, are nevertheless capable of englobing its spores and preventing their development. This is true, for instance, in case of anthrax in animals ordinarily immune, as, for instance, the frog and fowl. If, however, in these very animals the vitality of the phagocytes be affected—as by cooling in fowls or heating in frogs—phagocytosis is so far interfered with that the spores germinate within the enfeebled leucocytes and the entire organism is infected. (*Vide* also Plate II. Fig. 1, illustrating diapedesis.)

Hæmoglobin.

The principal interest of the red blood-corpuscles for the surgeon, aside from their relative number and shape, inheres in their relation to hæmoglobin, and hæmoglobin is of particular interest here because much can be learned by estimating the proportion in which it be present. That the amount contained in the blood varies within wide limits under different conditions has long been known. The ideal normal standard is present in but a small proportion of cases, even in strong young men in the third decade of life. The average is considerably lower and can scarcely be placed above 90 per cent. Females show a smaller amount than males—3 or 4 per cent. less. After hæmoglobin loss, as after surgical operations, much can be gained in the matter of prognosis by estimating the speed of its regeneration. With regard to how much actual hæmoglobin loss a patient can bear, it seems to be more important to determine how much still remains in the body. The minimum is apparently 20 per cent. In three cases dying of collapse after operation Mikulicz found only 15 per cent. remaining. The rapidity of regeneration is a fairly accurate indication of improvement in every other respect. Regeneration is interfered with by constitutional syphilis, and, on the other hand, is often apparently favored in cases of tuberculosis. In malignant tumors the average of hæmoglobin is reduced to about 60 per

cent., and in these cases also complete regeneration is materially retarded. Incomplete removal or recurrence of cancer prevents typical regeneration or restoration, while after successful or radical removal complete restoration to the previous standard, often with positive gain, is obtained. Thus, a woman who had gained thirty pounds after resection of a cancerous pylorus showed after three months hæmoglobin repair to the amount of 65 per cent. A prognostic significance often attaches to the accurate estimation of hæmoglobin at intervals after removal of malignant tumors.[1]

[1] See my *Lectures on Surgical Pathology*, p. 13.

CHAPTER III.

INFLAMMATION.

By Roswell Park, M. D.

Inflammation is an expression of the effort made by a given organism to rid itself of or render inert noxious irritants arising from within or introduced from without (Sutton, modified).

After having duly considered hyperæmia as a phenomenon having an identity and termination of its own, we are prepared to study the more complex processes implied under the term **inflammation**, the first of which is the hyperæmia already considered. The characteristic of the truly inflammatory process is that it does not stop with mere congestion nor with any of its above-mentioned terminations, but goes on to something more complex, now to be described. It must be understood, therefore, in this consideration that hyperæmia here is the first act of the vessels, resulting from peculiar stimuli which must shortly be considered. Even the hyperæmia seems to be now more distinct than under other circumstances, and along with the dilatation of vessels and the stagnation of blood-current the capillary vessels now seem crowded with blood-corpuscles to an abnormal degree, the rapidity of their motion is checked, and there is accumulation of blood-cells along the walls of the small veins, to which they seem to adhere as if by some new cohesive property. The result is that before long the vessel-wall appears to have received a new coating of white corpuscles, this being more marked in the veins than in the arterioles, while in the latter the red are more numerously mingled with the white than in the veins, in which the distinction between the two classes of cells is better maintained.

Next comes the phenomenon whose clear recognition and description is inseparably connected with Cohnheim's name. This is known under different names as **migration or diapedesis of the leucocytes.** The programme is about as follows: A little protrusion of the vascular wall, a marked alteration in the shape of a leucocyte, which yet adheres to this point of its lumen, and then the curious fact so often seen under the microscope—the gradual passage of this cell through the vascular wall, from its inner to its outer side, by what is generally known as its *amœboid movement.* This migration of the leucocyte is not confined to its mere escape from the restriction of the vessel-lumen, but goes on to an indeterminate extent after it has detached itself from the outer surface of the vessel. This seems to occur by virtue of the same amœboid characteristic which it exhibited in passing through between the cells of the vessel itself. If this occur at one point, it occurs at innumerable points, in consequence of which a large number

of leucocytes escape into the tissues of the part involved. This diapedesis occurs most markedly from the smaller veins, to a less extent from the capillaries. The cells which escape from the latter are usually accompanied by more or less red cells, the consequence being that the exudate which necessarily occurs at the same time is more or less tinged with the coloring matter of the blood, and is known as a hemorrhagic exudate. (See Plate II., Fig. 1.)

The above phenomenon, described in so few words, is in its minutiæ a really complex one, depending on a variety of causes not easily appreciated; but it is at least positive and well known, because it can be observed at will in the mesentery or web or tongue of certain animals which can be confined upon the stage of the microscope. The *phenomena of inflammation*, therefore, comprise, first, *hyperæmia*, and then *escape* from the blood-vessels of the *corpuscular and fluid* elements of the blood. The former may be due, as already seen, to various irritations of a non-specific character; while, as we shall learn, the latter practically never take place save when the irritation has been, as pathologists like to say, specific or infectious.

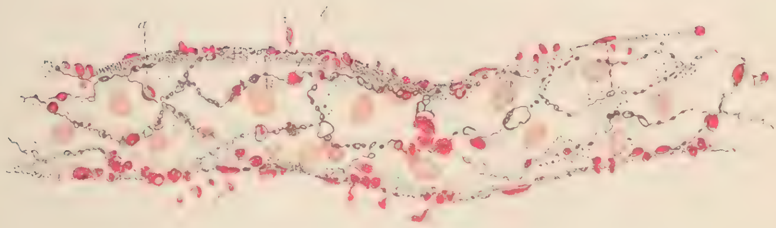
It would, perhaps, be too much to say that no corpuscles may escape from the blood in a condition of true hyperæmia, but it is speaking accurately and yet comprehensively to say that such congestion is not characterized by corpuscular emigration, whereas the essential phenomena of true inflammation are never met with save in connection with such escape. Experimental pathologists have long sought the explanation for this difference, and some have thought to explain it on the theory of changes in the vessel-walls; others by loss of tonus in the vessels—*i. e.* their inability to resist dilatation; others yet on the hypothesis of a peculiar attraction between the vessel-walls and the corpuscles circulating within them, or by a concentration of blood-plasma, or by vital attraction between the various elements of the blood; while still other hypotheses, even less tenable than these, have been advanced in no small numbers. Certain it is that the condition of vascular tonus is more marked than in simple hyperæmia, and that the character of the fluid as well as of the solid exudate is more distinctive. There is greater relaxation of tissues, while the intensity of passive congestion, as well as of active, is often so much heightened that rapid gangrene ensues unless this tension be relieved. The freedom of transudation also interferes with the facility with which the lymph-channels may carry away fluid, and gangrene is thereby the more easily produced. In proportion to the corpuscular elements would be the richness of the albumen strength of the fluid exudate. It is characteristic of active inflammatory exudates that they contain so much albumen as to easily coagulate, while this is much less true of passive exudates, which are for the most part very fluid.

The phenomena of true inflammation comprise practically the rôle played by the three elements which conspire to produce those changes—namely, the *tissues*, the *blood*, and the *specific irritants* which are the primary causes of the entire lesion. Each of these must be considered separately.

All observers agree that in actively inflamed tissues the number of cells is very greatly increased. A certain increase may be accounted for by that which has been already described—namely, the escape into the tissues of the wandering cells from the blood-vessels. But neither this alone nor the products of their rapid proliferation are sufficient to account for all the cells found in the truly inflammatory condition. The older view, for which Virchow long contended without accurate contradiction, was that these cells were due to multiplication of those peculiar or proper to the part, since he showed how much their activity

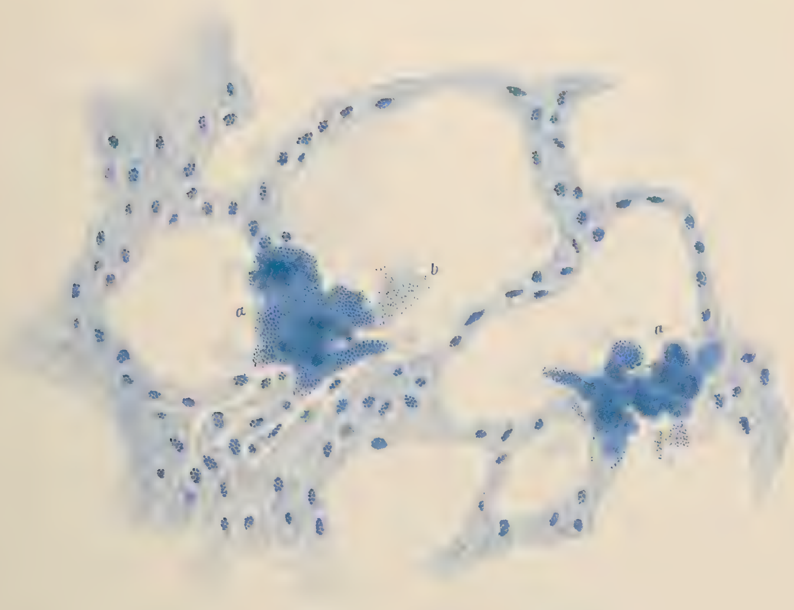
PLATE II.

FIG. 1



Small Vein showing Diapedesis of Leucocytes; *a*, Leucocyte escaping between Endothelial Cells; *b*, *c*, Leucocytes escaped; *f*, Leucocytes migrating toward centre of attraction. (Engelmann.)

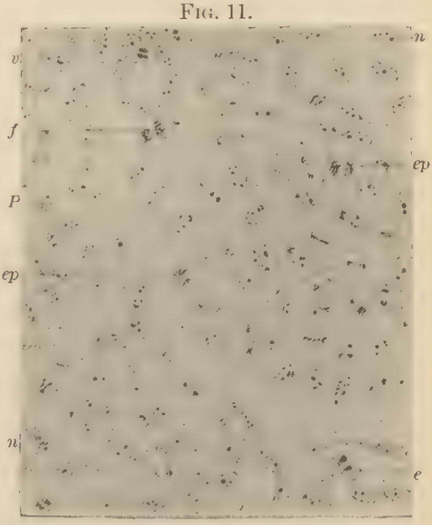
FIG. 2



Septic Thrombosis of Pulmonary Capillaries, after Puerperal Septicæmia. Showing rapidly increasing colonies of Streptococci. (Klebs.)

might be increased by what was then spoken of vaguely as "the inflammatory irritant." After Cohnheim had made plain the matter of diapedesis, his followers were prone to account for all the abnormally present cells by multiplication of those which had escaped from the vessels. In this way great contention arose between the followers of Virchow and of Cohnheim. We have since learned that the true explanation is afforded by the combination of both views. It is now well established that in connective tissue there are two varieties of cells—the fixed and the wandering—the former concealed in the trabeculæ of the intercellular substance, while the latter are small, ordinarily round in shape, much resembling the white corpuscles, possessed of amœboid characteristics, and having the power of changing position. These are known as the wandering cells, which meander through the lymph-spaces of the tissues or back and forth into and out of the blood-vascular system, their migration being regulated by causes not yet known to us. Under natural conditions their number is relatively small. Once given a true inflammatory disturbance, and they are reproduced with amazing rapidity; and their numbers, added to those produced by diapedesis of leucocytes, with the combined proliferative activity of both forms, serve to account for the new cells whose presence characterizes phlegmonous and other similar disturbances. That these wandering connective-tissue cells have much to do with these changes is shown by the recently pointed-out but unmistakable evidences of excessive activity known as **karyokinesis** (*i. e. nuclear activity*).

FIG. 11.



Karyokinesis; section from border of an inflamed gum: *ep*, karyokinetic division of deep epithelium; *v*, vessel divided transversely, showing proliferating endothelium; *e*, chromatin threads in endothelium cell; *f*, fixed cell undergoing nuclear division (Letulle).

Karyokinesis is a term introduced during the past few years, implying a very complicated series of changes with nuclear cell-division, with radiate arrangement of protoplasm around a polar centre, a division of the globule into two hemispheres of apparently clear protoplasm, with a granular arrangement of the chromatin which it contains, into peculiar surface-markings, while the achromatin is metamorphosed into threads, forming a more or less spindle-shaped arrangement stretching between the two poles. A synonym for karyokinesis is *karyomitosis*, frequently spoken of as *mitosis* for short. When a cell is about to undergo these changes the chromatin—that is, the part of the nucleus which stains easily—is increased and the nucleus disappears. Shortly after formation of the threads, which gather themselves in a series of loops pointing from the equator to the poles, a new membrane

is formed around this coil, and two nuclei are thus formed out of one. During this division the protoplasm undergoes also certain rotary changes of position, accompanied by segmentation of the protoplasm contained in the cell outside of the nucleus, so that two cells are thus formed. While nuclear division is usually bipolar, it may be multipolar; and in all probability multipolar division gives rise to those polynucleate cells often spoken of as *giant cells.* Karyokinesis is common not only in inflammatory disturbances, but in new growths of rapid formation, especially sarcomata, which are formed from mesoblastic cells, the same which have to do with connective tissue. Endothelial cells also undergo the same changes.

The wandering tissue-cells, or those which have been produced in the natural order of events, or those which seem to be the product of rapid breaking down of other tissue-cells (Ziegler), are not easy to distinguish from leucocytes. It is claimed, however, that they do not produce pus-corpuscles, but have more to do with repair. This claim, however, is not yet fully substantiated and needs to be corroborated.

It has been claimed also that many of the cells concerned in a vivid inflammatory disturbance are produced from intercellular substance whose component parts retain a power of conversion into more distinctly cellular elements in the presence of certain stimuli. At all events, when new cells appear their nuclei are first small and apparently destructive of protoplasm. They are so snugly fitted in between the bundles of fibres proper to the part that it would seem difficult to account for their presence by mere emigration. They are often seen where there is no sign of karyokinesis, which would appear to prove that they are of independent origin.

The peculiar characteristics of the leucocytes have been already described at considerable length in the preceding chapter. It must suffice, then, here to say that *during* the *inflammatory* attack the leucocytes are *increased in number*—*i. e.* there is a temporary leucocytosis which is the usual accompaniment of suppuration. (According to Cabot, this is regularly present in purulent, but not in catarrhal forms of appendicitis.) The recognition of this fact may be of great value in diagnosis. For instance, leucocytosis is rarely present in tubercular disease unless suppuration complicate the case. It is met with in suppurative osteomyelitis and in all cases of pocketing of pus. Moreover, when leucocytosis is present coagulability of the blood is increased. Of the various leucocytes, it is the mononuclear and polynuclear forms which are endowed with the most pronounced activity and which play the principal rôle among the blood-cells or phagocytes. That phagocytosis plays a most important part in the inflammatory process is a matter to be emphasized in more than one way and more than one place. The account of the process already given must suffice for descriptive purposes; the importance of the act, however, must be made most prominent in considering inflammation and suppuration. That the phagocytic properties of these cells are limited will be remembered when we recall that in certain instances phagocytes, which are incapable of defence as against the mature bacterial organism, are yet capable of englobing the spores and preventing their development. Nevertheless, the activities of even the most lively phagocytes are capable of being influenced and repressed by extremes

of heat and cold to which patients may be exposed, either locally or generally.

The Phagocytic Role of Certain Tissue-cells.

It must be definitely understood that phagocytes are not made up of leucocytes alone, but that particular cells belonging to certain tissues participate in this protective work. Next most important to the leucocytes are probably the endothelial cells of the vessels, which, as embryology teaches us, have retained some portion of their original mobile activity. Endothelial cells are certainly endowed with contractility, because it is by virtue of this that stomata are left in the vessel-wall through which the leucocytes escape. Numerous observers have proven that the endothelial cells often become overloaded with bacteria, this being perhaps particularly true in the liver. After death from malaria the endothelial cells of the liver are found filled with the plasmodium. When pigeons die with the septicæmia of swine almost all the endothelial cells of the blood-vessels of the body may be seen choked with microbes. Inasmuch as these organisms are non-mobile, their presence within the endothelial protoplasm can only be regarded as due to activity on the part of the tissue-cells. The lymphatic endothelial cells also are extremely active, while the ordinary connective-tissue cells are much less so. So, too, the basophile cells or *Mastzellen* of Ehrlich seem to be active in this direction.

Chemotaxis.

Having considered briefly the cells which take prominent part in the inflammatory process, and the escape along with them of the fluid portions of the blood, whether these coagulate or not, it is necessary before speaking of specific factors to discuss for a moment that which induces the above cells to act in this way. That there is a peculiar, even a mysterious, attraction which brings specific irritant and phagocyte together has been for some time recognized, but it remained for Pfeffer to study it carefully and to give it the name by which it now passes—*i. e. chemotaxis*—while others have widened our knowledge of it.

Chemotaxis is a term implying a peculiar property of *attraction and repulsion between cells*, both animal and vegetable. It mainly pertains to vegetable cells alone, and has been offered as the explanation of the sporulation of ferns, for example; but as it interests us most in this place, it is manifested between the animal cells of the human body and the bacteria, which are vegetable cells. As the result the former—*i. e.* the phagocytes—having power of migration, are drawn toward the latter. To be more accurate, this mutual or peculiar attraction is known as *positive chemotaxis*, it being also known that exactly the reverse obtains under certain circumstances, and that mobile cells will move away as rapidly as possible from certain organisms or substances for which they seem to have a repugnance, this being known as *negative chemotaxis.*

This chemotactic phenomenon is not confined to phagocytic cells alone, but is manifested as well among the bacteria and in many other unicellular vege-

table and animal organisms. Our best manifestations of it, however, probably occur in the poly- and mononuclear leucocytes. Just as mobile bacteria move toward nutritive material, so the phagocytes seem ordinarily to move toward that which, in the interest of the parent organism, they are to attack and destroy. It is chemotaxis apparently which impels phagocytes to take up and dispose of certain cells, as during atrophy or during the process of sloughing and separation of dead or inert tissue. It is a combination, apparently, of chemotaxis and phagocytosis by which the tadpole's tail is separated when the animal becomes the mature frog. It is this combination, in fact, which leads the phagocytes to act everywhere as scavengers for our systems and makes them our best friends. It is apparently the albuminoid material of bacterial cells which exerts a positive chemotaxis and attracts the phagocytes, which are brought to the infected area, as it were, by an irresistible magnetism. The chemotactic activity of bacteria may be exerted by them either living or dead. The explanation of giant cells in tubercle is probably the transformation of mononuclear leucocytes which have been drawn toward the bacilli in their rôle as phagocytes, and which, having performed their duty or having migrated in unnecessary numbers, undergo well-known transformation into the epithelioid and giant cells characteristic of the pathological tubercle. One may quote here to advantage Metchnikoff's statement that tubercle is composed of a collection of phagocytes, mesodermic in origin, which move toward the spot where the bacilli are situated and englobe them. The polynuclear cells which englobe the bacilli quickly perish, and then with the microbes which they contain are disposed of by the mononuclear phagocytes, which on account of their relative size have been classed under the name *macrophages*. This has to do, however, rather with chronic inflammation, miscalled, which will be considered later.

Specific Irritants.

These are essentially living organisms, grouped for the most part among the bacteria, fungi, and the protozoa, the first named being by far the most frequent. Before a lesion can assume the type of inflammation as here understood some one or more of these organisms must have secured an entrance into the tissues, the circumstances determining such invasion being considered a little farther on. It is these living organisms which, having once invaded the tissues, determine that most active congregation and proliferation of certain cells which we have just described under the head of Phagocytosis. When once the irritants are present, there begins that very active conflict which Virchow has so graphically alluded to as *the battle of the cells*. Now the mysterious chemotactic properties of the component substances manifest themselves, and now phagocyte is drawn toward bacterium, or the reverse, while the tiny war goes on with sometimes varying results, it being a question which can prove victor in the conquest. This is no fiction of the imagination, but is again a contest which may be seen under the microscope in certain of the lower animals, while its results may be seen in the examination of pus from any human source. In another place I have likened also this conflict to that in which certain of the enemy resort to poisoned weapons, because modern biological chemistry has now shown very evidently that it is a part of the life-history of many of these micro-organisms to produce, probably as excretory products, albuminoid or other substances having sometimes extremely toxic properties. And so it comes about that in many of the surgical infections, while the local destruction is produced by the actual death of tissues which have been invaded by micro-organisms, the general or systemic symptoms, ordinarily spoken of as the *toxic* symptoms, are literally due to poisons generated in the

infected area, dispersed throughout the system, and often proving fatal.

The *local effect of these specific irritants* when they are not promptly attacked, devoured, and removed by phagocytes is *pus*, which means cellular death, or gangrene, which is death of masses of cells which have not had time to separate from each other. Pus, then, is the ordinary consequence of the contest above alluded to, and *each pus-cell represents the dead body of a phagocyte* which has perished in the attempt to protect the parent organism from harm. That it has died valiantly can almost invariably be determined, because within its dead body may be seen the body of one or more of the minute invaders which it has attacked. This, then, is the light in which inflammation and infection should be viewed.

In other words, we may have escape of fluid portions of the blood, which may or may not coagulate; we may even have some escape of corpuscular elements with some activity in the extravascular cells, which shall lead to temporary or even permanent enlargement of a part; all of which may be provoked by injury or by the presence of certain chemical irritants within the blood or tissues; for example, alcohol, uric acid, etc. But the factors which provoke the greatest activity on the part of intra- and extravascular cells, and which determine the richness in albumin of fluid exudates, or their prompt coagulation so soon as blood-serum has escaped from the vessels, and which particularly determine the furious rush of phagocytes and that kind of intercellular conflict which leads many of the contestants on both sides to death, is produced solely by living organisms introduced from without, whose presence at the point of inflammation is abnormal and injurious, which are offending substances in every respect, while the whole phenomenon of inflammation is an expression of an effort to rid the system thereof. Taking this view of the subject, there is a most important distinction between hyperæmia and its consequences, which is absolutely a non-infectious condition, and inflammation and its consequences, which is always an infection and is always followed by more or less death of cells, the same being often extruded in a semifluid mass known as *pus*.

Next must be studied the—

Circumstances which Favor Infection.

1. The Virulence of the Infecting Organisms and the Amount Introduced.—There is the widest difference between various forms of micro-organisms in the matter of virulence; and it is true that there are very great differences between the same species under different circumstances, these differences depending on conditions as yet absolutely unknown. With certain organisms it is enough to infect an animal with one alone in order to bring about a fatal result, this meaning that the organism itself is extremely virulent and the animal extremely susceptible.

In a guinea-pig, for instance, a single virulent anthrax bacillus will produce death, whereas in a more resistant animal many are required, and in yet others there is absolute immunity against the disease. Man is much more susceptible to the pyogenic organisms than most of the lower animals, which is one reason

why wrong deductions have been drawn from many experiments, and why veterinary surgeons, who are so careless of all antiseptic precautions, yet, as a rule, have good results in work which, done after the same fashion on the human being, would be inevitably fatal. It is one reason also why one may draw false inferences from experimental work done, for instance, upon dogs, which survive many an operation which can scarcely be successfully repeated upon a human being. The influences which affect the vitality and virulence of micro-organisms are most numerous and widespread. Temperature, sunlight, moisture or dryness, association with other bacteria, source, are but a few of the conditions known to be more or less operative. Inoculation of a small number of certain bacteria may be harmless: up to a certain number it may produce only a local disturbance, like abscess, while a still larger dosage may produce fatal results. This is not the case with all, however, but only with some organisms. Bacteria which have been repeatedly passed through the animal body become more virulent than those cultivated for many generations in test-tubes in the laboratory. This variable virulence is especially characteristic of the colon bacillus, the anthrax bacillus, and the micrococcus of erysipelas. Nor does it always follow that the most virulent organism is necessarily cultivated from the most toxic or serious manifestation of its activity.

2. **Association.**—Bacteria are seldom found in pure cultures under natural conditions. By mutual association remarkable changes are produced, sometimes in the direction of enhanced virulence, sometimes in the direction of attenuation of effect. Certain organisms, extremely dangerous alone, lose their power when combined with others, while still others have their virulence increased to a rapidly fatal degree. In fact, these effects are so strange and so contradictory that no law governing them has yet been formulated, it being necessary to establish each case by experimental investigation. The virulence of the anthrax bacillus under ordinary circumstances is well known, as is also that of the streptococcus of erysipelas in man. Yet when these two organisms are introduced simultaneously the mixture is apparently wellnigh harmless. On the other hand, the simultaneous inoculation of certain other species greatly increases the danger from either alone. The diplococcus pneumoniæ when combined with the anthrax bacillus seems to have a greatly augmented power.

3. **Hereditary Influences.**—The fact that immunity against certain infections and susceptibility to other conditions are transmitted from parent to offspring is one which admits of no dispute. The explanation, however, is almost as remote from us to-day as it ever was. But the recognition of the fact is of the greatest importance to all practising surgeons. That bacteria frequently enter through wounds and bruises is self-evident, but we all know that such wounds are more likely to suppurate in some than in others, and the causes of infection in some are, to a certain extent, connected with hereditary habit of tissues. The same causes influence not merely liability to infection, but its severity and character. There are undoubtedly also local as well as general variations, and it is very certain that among these the results of bruising or contusion are by far the most prominent. There is also undoubted experimental evidence that under certain circumstances bacteria produce only local lesions, whereas under others they produce general and even fatal infection.

This brings up, in fact, the whole subject of **immunity**, which must be divided into the (*a*) *natural* or *hereditary*, and the (*b*) *acquired*. Natural immunity is, to some extent, of racial origin. Ordinary

sheep are, for instance, extraordinarily susceptible to anthrax, but the Algerian sheep, which differ less from the others than do certain races of mankind from each other, are practically immune against anthrax. There are the same differences between the common house-rat and the white rat. Morphological differences, however, do not explain this, for the negro is relatively exempt from yellow fever, and it is said that the Japanese do not have scarlatina. *Acquired immunity*, on the other hand, is the result of accidental circumstances. It may be conferred by one attack of certain diseases, as yellow fever, scarlatina, etc. It is, however, less complete and not so permanent as the natural form. That acquired immunity may be produced experimentally in numerous ways is of very great interest, but is a subject which can hardly be discussed here at length. Two facts, however, which we have learned experimentally, afford not a little light upon certain infections in the human being. One is that *extreme fatigue* will so reduce natural immunity that infection may occur. This is shown, for instance, by making a rat, which is ordinarily immune against anthrax, tire itself out by working in a wheel cage, after which it can be infected. So, also, certain animals can be infected with disease to which ordinarily they are immune after plunging them in a *cold* bath or *elevating* their *temperature* considerably above the normal.

If we are permitted to draw any inferences from such laboratory investigations, they shed not a little light upon the favoring influences of fatigue and exposure as concerns the human individual. So, also, by producing artificial diabetes in animals which are ordinarily immune, or by altering their diet, or by injecting certain substances, such as phloridzin, curare, and others, their immunity may be reduced or practically abolished; so, also, by starvation, or by removal of the spleen, or combining different bacteria as in an artificial mixed infection. These facts all have an important bearing on the etiology of disease in the human being, because they are all capable of being paralleled in our daily experience.

4. **Local predisposition** is a factor of almost equal importance. Once given a distinct infection, and hyperæmia is sometimes a contributing cause of inflammation. *Per contra*, anæmia of tissues seems to be again a favoring condition. In parts involved in chronic congestion the blood flows more slowly, while the vessels are dilated and apparently susceptibility is increased. Infection here produces a type of disease ordinarily spoken of as *hypostatic inflammation*. General anæmia, again, is a predisposing cause, while toxæmias, including diabetes, etc., are still more so. The liability of diabetic patients to suppurative and even gangrenous infections is proverbial. The presence of foreign bodies has much to do also, and, infection once having occurred along with its introduction, the presence of a foreign body will nearly always excite suppuration; otherwise, it will ordinarily remain inert. The withdrawal of trophic nerve-influences also apparently permits infection, as is instanced by the ease with which bed-sores form in paralytic patients. Obstruction to the circulation or to escape of secretions more easily permits infection: for example, in the appendix, in the kidney, in the gall-bladder, the salivary glands, etc. Furthermore, one may formulate a quite comprehen-

sive statement and say that all such lesions as solutions of continuity, hemorrhages, degenerations, vascular stasis produced by strangulation, etc., and all perforations, increase more or less the liability to infection.

The ease, for instance, with which the colon bacillus passes through the coats of intestine which have been in the slightest degree disturbed or abraded is remarkable. It often happens that in the fluid contained within the sac of a strangulated hernia these bacilli, and sometimes other organisms, are found in great numbers. (In consequence the sac should be carefully disinfected before reduction is effected.) Therefore, without the existence of recognizable lesions these bacteria sometimes migrate in this way, and thus perhaps enter the circulation.

It has been held in time past that the presence of blood within a wound was most undesirable, and hæmostasis has been a strenuous insistence of all recent surgical writers, it being held that blood-clot offers a most favorable nidus for the development of bacteria. It has been more recently shown that virulent organisms injected into blood-clots occasion no suppuration, and our views are of late somewhat modified with regard to the danger of retained clot. In fact, it has been recently utilized in the healing of a certain class of wounds. Retained blood which produces undue tension is a source of danger, but that which is unirritating by its presence and uncontaminated by bacteria is capable of speedy organization.

5. **Pre-existing Disease.**—Here are reckoned—first, *previous and long-existent toxæmias*—*e. g.* syphilis, diabetes, scurvy, etc. Other conditions, like lithæmia, cholæmia, acetonæmia, and the various conditions represented by oxaluria or in which acetone, peptone, and excess of uric acid are found in the urine, come also under this head. One need never be surprised to find suppuration occurring in those cases in spite of due observance of all ordinary precautions, since by their existence immunity is destroyed and vulnerability increased. (*Vide* also chapter on Auto-infections.)

Recent toxæmias also have important bearing in this same respect. For instance, after typhoid fever and other acute wasting disease, including the exanthemata, surgical operations are sometimes followed by failure, and should always be postponed until complete recovery, except in cases of emergency. The condition to be hereafter described as *enterosepsis*, and which in time past has been spoken of under many different names, as fecal anæmia, stercoræmia, etc., is one which positively makes dangerous the performance of all operations, and which certainly predisposes to septic disturbances of all kinds. The post-puerperal state is also one in which operations are to be avoided if possible.

Certain *anatomical changes peculiar to the various ages* also belong in this category. Old age with its accompanying arterial sclerosis, its cardiac debility, and other well-known tissue-alterations, favors sluggishness of wound-repair and leads not infrequently to sloughing or to bed-sores. Amyloid changes betoken impaired vitality. Children are much more liable to acute osteomyelitis than adults. Nursing infants are apparently exempt from many of the infectious diseases, but possess relatively small power of vital resistance to surgical operations. General anæmia and impaired nutrition of

the body predispose to most infections, acute starvation notoriously so.

6. **Personal Habits and Environment.**—*Diet* has much to do with tissue-resistance. Rats fed on bread are more susceptible to anthrax than those fed on meat. Hunger makes pigeons highly susceptible to the same disease, and artificial immunity induced in various animals is quickly destroyed by starvation. Prolonged thirst seems to have the same result. Prolonged fatigue notoriously reduces immunity, as already mentioned. The various drugs which destroy red corpuscles impair immunity, and even by injection of water into the circulation the bactericidal power of the blood is reduced. White mice fed with phloridzin, which produces artificial diabetes, become highly susceptible to glanders, from which they are ordinarily exempt. In this connection may also be mentioned the various toxæmias alluded to under the previous heading, which may proceed from the intestine, from the genito-urinary tract, and probably also from other sources. Climate has more or less to do, as also extremes of weather, with power to resist infection or to survive serious operations. Dark habitations, poorly ventilated, constitute surroundings which notoriously predispose to infection of all kinds. Rabbits inoculated with tuberculosis and confined within a dark cell, badly ventilated, become rapidly diseased, while others similarly inoculated, but allowed to roam at large, present but slight evidences of the affection. Certain occupations predispose to certain diseases. This is pre-eminently the case, for example, with workers in mother-of-pearl, who are exceedingly liable to a particular form of osteomyelitis; and with those who make phosphorus matches, who are prone to suffer from a peculiar necrosis of the lower jaw: that prolonged suppuration may produce such changes in the blood and tissues that vital processes of repair, cell-resistance, and chemotaxis may be so far interfered with as to facilitate subsequent infection, is a matter upon which I have elsewhere insisted. So, too, with regard to those agents usually considered most desirable—*i. e.* antiseptics—which sometimes set up toxic disturbances of minor or serious degree, especially when injudiciously used, by which the very effect we desire to gain is negatived or destroyed. It occasionally happens that in the use of these remedies in too great strength chemical reaction between vital fluid and antiseptic leads to decomposition of one or both; the latter being decomposed, its previous properties are lost, and the exposed tissues unfavorably acted upon.

Finally, the *influence of local injury to tissues*, particularly of contusions which cause tissues to lose their vitality, is strenuously insisted upon by all, and is spoken of repeatedly in other places in this work. Many tissues will succumb to inoculation after bruising, ligature *en masse*, etc. which before such injury are not in the least disturbed.

7. **Fœtal Infection.**—It is only in a very limited class of cases that infection can be transmitted from mother to fœtus, but there are instances of this kind in which the surgeon is deeply concerned. As Welch has stated, syphilis is the only infection capable of direct transmission through the ovum or spermatozoon; but intra-uterine infection may occur in many ways, and many diseases may be thus

transmitted. The placenta is usually regarded as a perfect filter; nevertheless, it is occasionally passable by micro-organisms. These may be caused by pre-existing lesions in the placenta or by the virulence and activity of bacteria. It is known that in animals the bacilli of chicken cholera (inoculated into the mammalia), of symptomatic anthrax, and the pyogenic cocci frequently traverse this barrier. In mankind infection *in utero* has been observed in small-pox, measles, scarlatina, relapsing fever, syphilis, tuberculosis, croupous pneumonia, typhoid fever, anthrax, and surgical sepsis.

Sources of Infection.

That the effects of bacterial invasion may be anticipated and guarded against most effectually it is necessary that the practitioner be thoroughly familiar with the sources from which they come, and the localities in and about the body which they most commonly inhabit or where they are met with in largest numbers.

Skin and Mucous Membranes.—Of all possible sources of infection, the skin itself is probably the most fertile. It is exposed to contamination by air and by everything which may come in contact with the body, and there is perhaps no organism ever met with in disease which may not be found upon its surface or within its recesses. In fact, these recesses, such as the crevices beneath the nails, the spaces between the toes, and the various pockets like the tonsils, the axillæ, etc., are those most commonly inhabited by micro-organisms.

Welch has described a special form of staphylococcus, which he calls the *S. epidermidis albus*, which he considers a regular inhabitant of the normal skin, just as the colon bacillus is of the intestinal canal. He deems it a variety of the S. pyogenes albus, possessed ordinarily, however, of but feeble pyogenic power, and frequently present in layers of epidermis lining the hair-shafts—*i. e.* extending deeper into the skin than can any means of cutaneous disinfection. While it would be impossible, then, to dislodge these by most careful scrubbing, it is quite possible in passing sutures through the skin to carry this organism with them; and this undoubtedly is a common explanation of stitch-hole abscesses or much deeper and more serious infections. It is an argument, therefore, in favor of passing all sutures through the skin from within outward, which is particularly true in abdominal work. Like all other organisms, it varies in virulence, but this very fact makes the skin one of the greatest sources of danger.

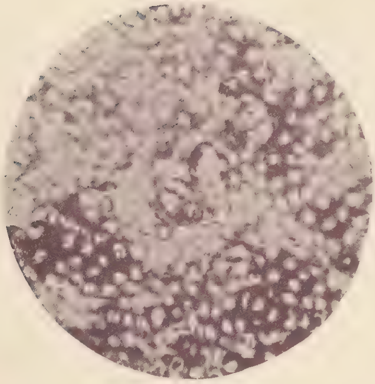
Bacteria may penetrate the skin by means of three different routes—namely, the sweat-glands, the hair-follicles, and the sebaceous glands by means of their regular openings. The hairy appendages of the skin are even greater sources of danger than the skin itself, since a direct path of infection into the depths of the skin is afforded by their follicles. Experimentally it has been shown that when bacteria are rubbed into the skin where there are no follicles, there is absolute freedom from infection, whereas the reverse is equally true, and it is clinically generally recognized that furuncles and carbuncles form almost exclusively in those parts provided with hair and sebaceous glands.

Contamination with the soil is always a source of danger, since ordinary black earth especially contains two organisms of ordinarily greatest virulence and danger—namely, the bacillus of tetanus and of malignant œdema. Smegma also contains saprophytic and sometimes other organisms in great abundance. Particularly often it contains bacilli known as the smegma bacilli, which are not infrequently mistaken for the tubercle bacillus, having certain properties common with it. Cerumen, too, is loaded with bacteria, although it seems to be a less prominent source of danger than most of the other secretions.

The mucous membranes are in constant contact with micro-organisms, and furnish conditions in many respects favorable for their rapid development.

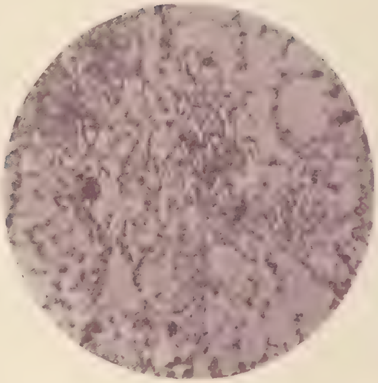
PLATE III.

FIG. 1.



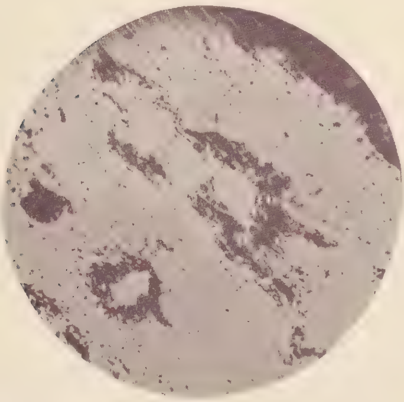
Artificial Dental Caries—in cross section; tubules filled with bacteria. (Miller.)

FIG. 2.



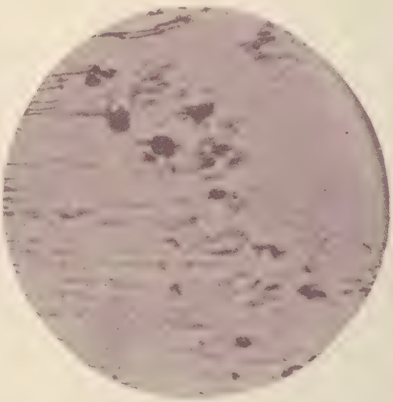
Putrid Tooth Pulp. Infection of Dental Tissue. (1–1000.) (Miller.)

FIG. 3.



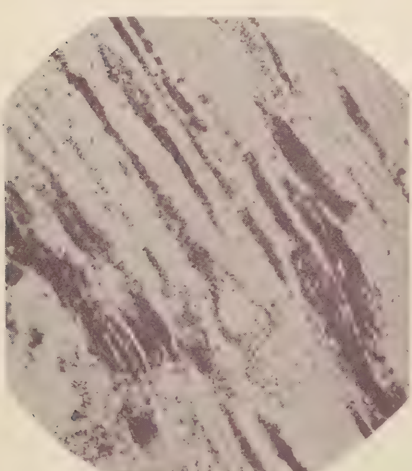
Dental Caries; disappearance of dental tissues as result of presence of bacteria. (Miller.)

FIG. 4.



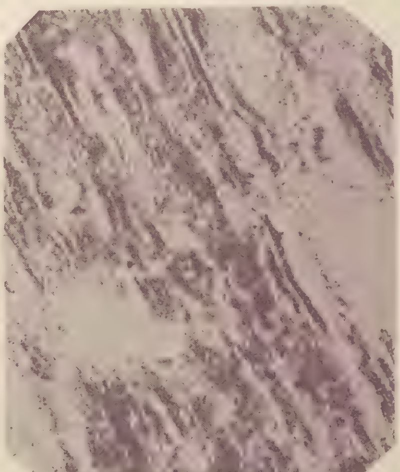
Dental Caries; tubules filled with cocci. (Miller.)

FIG. 5.



Dental Caries. (1–500.) (Miller.)

FIG. 6.



Dental Caries; tubules plugged with cocci. (1–500.) (Miller.)

Nevertheless, the latter is interfered with, and often inhibited, by certain mechanical and chemical influences which afford us protection. The conjunctiva is an extremely exposed membrane, which harbors, however, but a relatively small number of bacteria under ordinary circumstances. The tears before escaping from the conjunctival sac are sterile, and are probably saline enough to act as an antiseptic bath for the cornea. Moreover, by free escape of secretion through the nasal duct the conjunctival sac is kept constantly irrigated, to which is mainly due, in all probability, its ordinary healthy condition, since we know how commonly lesions follow obstruction to the lachrymal duct. The horrible results of Egyptian ophthalmia—*i. e.* the pyogenic form of conjunctivitis—are familiar to all travellers in Egypt. This disturbance has by Howe and others been clearly shown to be in the main due to the flies which are attracted toward the eyes of the infants, and which are most pronounced carriers of infection, while the superstitious notions of the parents restrain these children from instinctive protection of the eyes when thus irritated. There is probably no greater common carrier of pyogenic infection than the common house-fly, and nowhere is this agency more abundantly demonstrated than in the hot climates of the Orient.

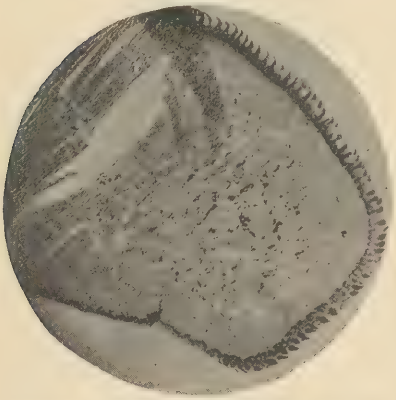
Upper Respiratory Tract.—The oral cavity and pharynx are never free from bacteria. Miller has studied over one hundred species that he has found under various circumstances in the human mouth. Some of these are pathogenic; others are apparently absolutely innocent. Many of the forms which grow in saliva will not grow in ordinary media. (*Vide* Plate III., illustrating infection of the teeth.) Miller has also shown that all forms of dental caries are but expressions of bacterial invasion even of those apparently most solid structures, the teeth; and of late we have been taught more fully that such invasion may extend far beyond the confines of the teeth alone, and may spread to various, even to distant parts, and produce possibly fatal mischief. Abscesses in the brain and extensive septic infections have been clearly traced to invasion along the line of the dental tubules. One of the most virulent of all the common inhabitants of the mouth is the pneumococcus of Fränkel, known also as the micrococcus lanceolatus of Sternberg. In virulence it is a most variable organism, but it is present in a virulent state in only 12 or 15 per cent. of cases of infection due to it. This is the organism which is the cause of lobar pneumonia, and frequently of broncho-pneumonia, as well as of numerous phlegmons and other inflammations of the throat, and which, getting into the general circulation through the tonsils or other possible ports of entry about the mouth, causes serious septic and inflammatory disturbances in widely distant regions. Aside from dental caries, a widely-opened port of entry is often afforded by those ulcerations around the margins of the gums which are produced by accumulations of tartar. Disease in the antrum of Highmore, for instance, and many other local destructions, are frequently caused in this way. (*Vide* Fig. 12 for example.)

The next most common port of entry is the *tonsil*, which contains a variety of crypts which are often filled with secretions or retentions loaded with bacteria. And one of the most common sources of an infection which leads to involvement of the cervical lymph-nodes in tubercular disease is an infection springing first from the tonsil or the teeth.

In spite of the fact that myriads of bacteria are swept into the nasal cavities with the air we breathe, relatively few are met in the nose.

A peculiar capsule bacillus, closely allied to that described by Friedländer, has been found in a number of cases of ozæna, while the pneumococcus of Fränkel is also often found there, and is known to produce abscesses of the brain. One specific organism—namely, that of *rhinoscleroma*—concerns the nose almost solely, its first ravages at least being met with in this location.

Fig. 12.



Invasion of tongue by pneumococci after subcutaneous infection (Miller).

Immunity from infection in the nose is largely produced by the bactericidal properties of nasal mucus, which have been definitely established. It is certain, however, that from the nasopharynx pathogenic bacteria work their way along the Eustachian tube and produce serious disturbance in the middle ear, from which it may spread farther. The question of the permeability of unbroken mucous surfaces to organisms, particularly to tubercle bacilli, is one of very great importance. There is much reason to hold to the possibility of such migration, although experimental experience is wanting. Clinical evidence, however, is very strong. It would appear that tubercle bacilli may, and occasionally do, enter the lymphatic circulation without causing recognizable lesion at the point of entry. Nevertheless, a careful search will often reveal that which a casual investigation may not show.

Alimentary Canal.—Probably more micro-organisms enter the alimentary canal than gain access in any other way, these coming both from food and drink as well as air. Once within its confines, relatively very few of them are capable of prolonged existence. Welch states that the meconium of new-born infants is sterile, but that within twenty-four hours it usually contains abundant bacteria. That bacterial infection through this passage-way is a very fertile source of non-surgical lesions is well known. The possibility of surgical infections being produced in the same way is both more remote and less demonstrable. Naturally, anaërobic organisms find here more favorable conditions, and even extremely acid or extremely alkaline conditions do not serve to destroy all such life. Pyogenic cocci are often present, and are frequently found, in peritoneal exudates. In the intestines of herbivorous animals the tetanus bacilli and those of malignant œdema are regularly found. The fungus of actinomycosis also easily finds its way into the bowel along with ingested food. Under ordinary conditions the bile in its natural reservoirs is free from bacteria, but the colon bacilli and pyogenic cocci often invade these precincts.

Genito-urinary Tract.—Even the healthy urethra always contains bacteria. While these may wander upward to an indefinite extent, there is every reason to think that the urine contained within the bladder in a condition of perfect health is free from bacteria, and that if such gain entrance they do not long remain. The same is true of the female bladder and urethra. The vagina contains organisms of many species, some of which do not grow on ordinary culture-media, but are to be

recognized by the microscope. While it is quite generally acknowledged that the vaginal secretion is, as a rule, possessed of bactericidal properties, there is as yet no satisfactory nor comprehensive explanation of this fact, its normal acidity not being sufficent in this direction.

The Milk in the Lacteal Ducts.—In a condition of perfect health milk secreted from the ideal mammary gland is sterile, but may easily become contaminated upon its exit from the nipple. Conversely, under many favoring conditions these organisms may travel into the lacteal ducts from the skin without, and thus contaminate the milk. In all probability, the breast corresponds in behavior to other glands whose ducts open upon the surface, and, while such openings invite entrance of bacteria, their migrations do not extend far from the surface unless some of the other conditions already mentioned predispose to further infection or extension.

In summarizing the general topic of possible **sources and paths of infection** we may say that bacteria may enter and exert deleterious action—

A. From within the system; and

B. From without.

A. *From within* they may get into the tissues either through the inspired air, through food and drink—*i. e.* ingesta—or by means of more direct inoculation, as, *e. g.*, by foreign bodies or by venereal contact. The danger through infection by inspired air is relatively very small, and concerns most probably a limited number of organisms, of which the tubercle bacillus is the most important. Foul air and air which emanates from sewers, cess-pools, etc., while most unpleasant to breathe and deleterious in many other ways, does not necessarily contain any micro-organisms which can be injurious. This fact, in opposition to generally-received notions, is, nevertheless, proven by recent investigations. The ingesta furnish the most fertile source of contagion from within, but the diseases thereby produced fall for the most part into the domain of medicine rather than that of surgery.

B. *Infection from without* the body may come by actual contact with previous skin or mucous lesions, and particularly from noxious insects and certain parasites. Among surgeons the principal sources of contact-infection to be enumerated and guarded against are—

1. Skin and hair;
2. Instruments;
3. Sponges or their substitutes;
4. Suture materials;
5. The hands of the surgeon and his assistants;
6. Drainage materials;
7. Dressing materials; and
8. From miscellaneous sources—*e. g.* drops of perspiration, unclean irrigator nozzle, a contaminated nail-brush, the clothing of the operator, etc.

While insisting here upon the recognition of these sources of danger, the precautions to be taken against them are to be considered under another heading, to which the reader must at present be referred.

Highly virulent pyogenic organisms of various kinds are frequently, if not always, present upon the exposed skin-surfaces of the body, where they remain inert, but where they are most favorably placed for such deeper implantation as may bring about septic disturbances. So, too, the viscera and normal fluids of the healthy body are free from bacteria, while, in fact, they seem to be intimately concerned with the vital processes of digestion, etc. Here, too, disturbance of normal conditions permits speedy entrance into the circulation with all its attendant possibilities for harm. It is probably harder to take the ideal precautions when dealing with mucous membranes than in any other part of the body. While wounds and deliberate surgical lesions of mucous surfaces or deeper parts covered by them, for the most part, heal satisfactorily, we never expect such ideal wound-repair as in external wounds which can be closed completely by suture. Nevertheless, we have here abundant demonstration that the mere presence of bacteria is not necessarily sufficient to interfere with healing.

One of the greatest sources of possible infection has of late been shown to be the presence of flies and other noxious insects, which act as carriers of infection. The Egyptian ophthalmia, which ruins the sight of 30 per cent. of the inhabitants of Egypt, has been shown by Howe and others to be due to infection by this mechanism; and a very simple bacteriological experiment will suffice to show that the foot-tracks of a single fly across a wound furnish abundant opportunities for infection with organisms which are presumably virulent. In fact, the danger of carriage of infection by this means is greater than from almost all other sources, except the use of improper materials during surgical operations.

The Elimination and Destruction of Bacteria.

Infectious micro-organisms, like the non-pathogenic forms, are often effectually dealt with after gaining entrance into the body by virtue of protective powers possessed by the organism and manifested in more than one way. Thus they are removed by excretion through certain emunctories, they are destroyed by certain living cells and normal fluids (blood-serum especially), or they die from lack of a pabulum upon which they can exist. The pyogenic bacteria are not infrequently eliminated through the urine, in which case they may cause temporary disturbance within the kidneys, or, if the dosage be continuous, the lesion may become not only permanent, but progressive. Thus, in pneumonia, in typhoid, in erysipelas, and in other acute infections these specific organisms are frequently found within the urine. Here is also often found the colon bacillus. Tubercle bacilli are present in the milk of cows which have extensive tubercular disease. Pyogenic cocci may even be excreted through the mammary gland after puerperal fever. Pneumococci are found in the milk of nursing-women with lobar pneumonia. Anthrax bacilli have been found in the sweat from the paw of an infected rat, and pyogenic organisms have been detected in the perspiration of patients suffering from septicæmia and pyæmia.

Conditions which Afford Protection or Immunity.

It is necessary to at least summarize the conditions which, in opposition to the many lesions described as favoring infection, serve now to produce immunity, or at least to increase vital resistance and decrease vulnerability. A summary of this will not long detain us. The ideal condition is that which is summed up in the generally recognized expression of "perfect health," under which condition the various secretions and fluids, possessing their normal acidity or alka-

linity, are sufficient to destroy or render inert harmful organisms which enter their precincts; where the skin is cared for by the habits of the individual in such a way as to prevent its being overloaded with harmful microbes, and where there is such perfect equilibrium of ingestion and excretion as to permit no extravascular excitement, no congestion, no exudate which may become infected—in other words, where the natural functions are performed in an ideal manner. Under such conditions almost any accident is survived and repaired without perceptible struggle, the tissues and fluids in their healthy state being abundantly able to dispose of such bacteria as may accidentally enter. Under these conditions the traumatic exudate is speedily absorbed, the hyperæmia of irritation promptly compensated for, and here we find those general conditions which surgeons everywhere rejoice to see, and under which they feel warranted in making any necessary interference. These, too, are the conditions where if, by accident, infection have positively occurred, as by introduction of a foreign body, phagocytosis is so prompt and the lymphatic filtration through the lymphatic nodes is so thorough that the worst that may happen is local suppuration. This general condition is met with in its most complete expressions where no hereditary influences have conspired to dwarf organs or impair their activity; where no poison, like that of syphilis or uric acid or alcohol, interferes with perfect nutrition and cell-activity; where exposure has not lowered tissue-vitality; where over-exertion and mental worry have not lent their aid in contributing to impair natural processes. These are the conditions which afford protection and under which the surgeon loves to work.

Classification of Infections.

We speak of infections in another way as *primary, secondary,* and *mixed;* and it is necessary, for purposes of accuracy at least, to make a reasonably clear distinction between them. By **primary infection** is meant infection with a single form of organism whose effects are prompt and speedy. Of this erysipelas or syphilis may serve as a good illustration, although in the latter instance the character of the *contagium virum* is not yet definitely known. Most of the acute infections, in fact, belong to the primary type.

Secondary infection means that after certain disturbances due to a primary infection—*i. e.* one of a given type—there occurs at some later period and from a distinct source another infection whose results may be more or less disastrous, and cause the case, at least for the time being, to assume a different aspect. We may have an illustration of this in the case, for example, of primary tuberculosis with distinct infection of a number of lymph-nodes, which, acting as filters, have caught in their tissue-net a large number of tubercle bacilli that, lodging there, have produced the usual well-known results and have practically converted the infected nodes into granulomata. In these infected masses well-known changes, such as those which follow tubercular infection—atrophy, caseation, calcification, etc.—may be occurring, when suddenly there comes infection of a *pyogenic* type and from another source, and suppuration of the granuloma is the result.

It is possible even to have a **tertiary infection**, of which the following may be a hypothetical instance: Primary infection with scarlatina or measles, by which vital susceptibility is in some instances notoriously lowered; as the result of this, secondary tubercular infection in an individual previously resistant; and, third, a suppurative infection, as above described.

In contradistinction to these distinct events, separated by an appreciable, sometimes a considerable, length of time, we recognize a **mixed infection**, where two or more organisms are implanted at or about the same time. A very common illustration of this is met with in most cases of gonorrhœa, in which there is a synchronous attack made by the gonococcus, which is a specific micro-organism, accompanied by staphylococci or streptococci, whose effect will complicate the case and make it assume a less particulate type of infection. Mixed infections may often occur in other ways, as syphilis and chancroid, chancroid and gonorrhœa, etc. Most cases of mixed infection belong rather to surgery than to general medicine, and constitute an apparent violation of the rule to which physicians often point—that two distinct infectious diseases are seldom communicated or acquired at the same time. Nevertheless, the facts remain as above.

Bacteria of Pus-formation.

Bacteria which act as agents in the formation of pus are collectively known as pyogenic organisms. These are divided into two groups:

A. *The Obligate;* and
B. *The Facultative.*

Obligate pyogenic organisms are those whose activity is always manifested in the direction of pus-formation, which seem to produce it if they produce any unpleasant action whatever. On the other hand, the *facultative* organisms are those which are known occasionally to be active in this direction, and yet which are not always nor necessarily so. The members of the group A are fairly well known and catalogued, and are not very numerous. On the other hand, there is reason to think that many organisms may have the occasional effect of producing pus, as it were by accident or at least in a way not absolutely natural nor peculiar to themselves, but are yet frequently found when there is no pus present. A suitable list of the facultative organisms, therefore, can hardly be made, and will not be here attempted, the effort being only to mention the more common organisms which play this facultative rôle. It must be mentioned also that even the adjectives "obligate" and "facultative" are to be accepted with some mental reservation, since staphylococci, for instance, may be met with even in the absence of pus, although nearly all that we know about these organisms implies that pus would be the result of their presence if one wait. Furthermore, there are certain other organisms, not, strictly speaking, bacteria, which also have the power of producing either pus or pyoid material. These will also be mentioned in their place. Some of them belong not only to the vegetable, but to the animal kingdom.

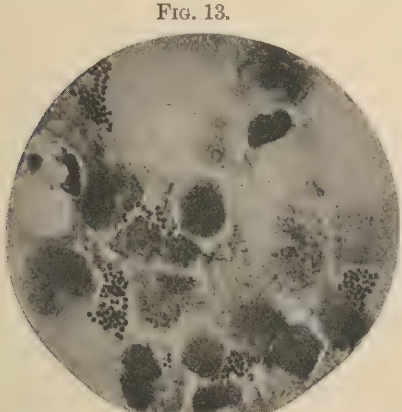
Obligate Pyogenic Organisms.—A. *The staphylococcus pyogenes aureus, albus, citreus,* etc.—These are minute spheroids, averaging eight-tenths of a micron in diameter, occurring usually in groups, sometimes showing a diplococcus appearance, found inside and outside the pus-cells, growing at ordinary temperatures on all media with and without oxygen, liquefying gelatin, coagulating milk, staining readily with all aniline dyes, surviving for a long time in dry pus, dying easier in comparatively high temperatures when moist rather than dry, of very variable virulence—the most commonly met with of all the so-called pus-organisms.

The *S. p. aureus* produces pigment as it grows, from which its name is taken. So, too, the *citreus;* the *albus* grows without pigment-formation. The *staphylococcus epidermidis albus,* more recently discovered, is probably a sub-variety, which grows and liquefies gelatin more slowly. Other forms of staphylococci—namely, the *cereus albus* and *cereus flavus*—have been described, but are seldom met with. They are of lesser degree of virulence.

One of the marked characteristics of the staphylococci as a group is the powerful peptonizing action which they exert. Moreover, the chemical products of their life-changes seem to be more potent both in a local and general way, leading to greater destruction of tissue in their immediate vicinity, with greater inhibition of the chemotactic powers of the leucocytes; that is, with more interference with phagocytosis, by which their progress would be interfered with. Their presence is often to be recognized by a peculiar odor, as of sour paste, which when detected should always lead to a prompt change of dressings and disinfection of the wound (by irrigation, spraying with hydrogen dioxide, etc.).

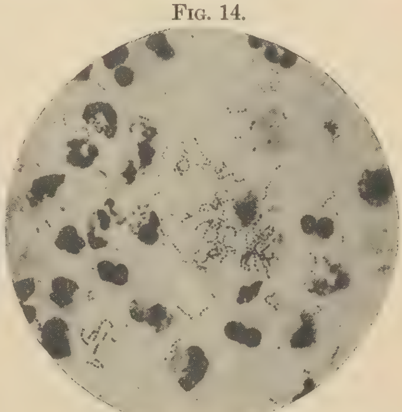
B. *Streptococcus pyogenes and Streptococcus erysipelatis.*—These two organisms do not differ in morphology or characteristics, and, while for some time considered as distinct from each other, are now by most observers regarded as identical. The streptococci grow in chains of variable length, and individual cocci vary in size. They

FIG. 13.



Staphylococci in pus: × 1000 (Fränkel and Pfeiffer).

FIG. 14.



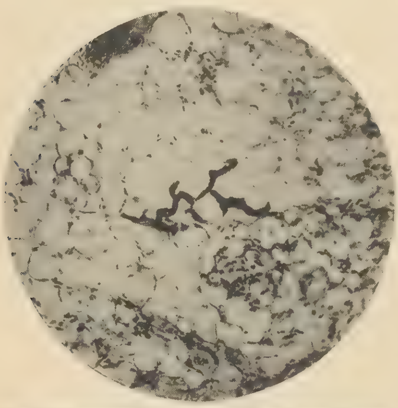
Streptococci in pus: × 1000 (Fränkel and Pfeiffer).

grow with and without oxygen, in all media, at ordinary temperatures, do not liquefy gelatin, stain readily, sometimes but not invariably coagulate milk, and vary very much in longevity. They differ extraordinarily in virulence as obtained from different sources.

There are many streptococci not included under the above head which are indistinguishable morphologically and in other respects, and yet which are in a measure or entirely free from all pathogenic activity in man. A careful biological study reveals remarkable and unexplainable transformation in effect as between the different members of this species, a part of which may be referable to conditions pertaining to the organism infected, but part of which apparently pertains to the bacteria themselves. It is held by some that scarlatina is an invasion by certain organisms of this class; this, however, is not yet definitely established. When found in the stools of children with summer diarrhœas they are regarded as indicating actual ulceration of the intestinal mucosa.

In contradistinction to the staphylococci, the streptococci manifest a strong predilection for lymph-vessels and lymph-spaces, along which they extend themselves with great rapidity. They have much less peptonizing power than the staphylococci (except in the absence of oxygen); hence streptococcus infection assumes usually the type of widespread infiltration rather than of circumscribed and distinct œdema. One sees remarkable instances of this in cases of phlegmonous erysipelas. It is suggested also that the peculiar manner of growth of the streptococci, in long chains which may coil up and entangle blood-corpuscles, has much to do with the formation of fat-emboli and with general pyæmic disturbances.

FIG. 15.



Staphylococcus infiltration of perirenal tissue, from a case of pyæmia; × 1000 (Fränkel and Pfeiffer).

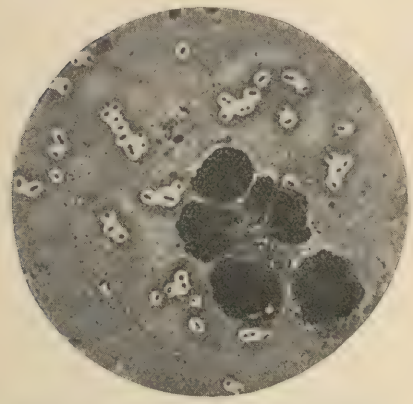
Both these bacterial forms have the power of producing lactic fermentation in milk; and it is quite sure that lactic-acid formation sometimes takes place along with suppuration in the human tissues, causing acidity of discharge, sour odor, and watery pus. It would appear also that these two pyogenic forms have less power of ptomaïne or toxine formation than many others, and, consequently, that the pyrexia attending suppuration or purulent infiltration is not always to be ascribed to this cause alone, for fever may in some measure be due to tissue-metabolism attending their growth, the metabolic products being pyretic. This is in a measure substantiated by the fever attending trichinosis, where the question of ptomaïne-poisoning has not yet been raised.

C. *Micrococcus lanceolatus*, known also as the *diplococcus pneumoniæ* or the pneumococcus of Fränkel and Weichselbaum, and as the *micrococcus of sputum septicæmia* of Pasteur and of Sternberg. This is a capsulated, lance-shaped coccus, occurring usually in pairs, sometimes in chains; it grows at ordinary body-temperature, does not liquefy gelatin, loses virulence and dies quickly in cultures, but may long survive in dried sputum or blood. In virulence and other properties it is extremely variable. It is of interest to surgeons because it causes many localized inflammations and is a frequent factor in causing septicæmia; it is very often present in the mouths of healthy individuals. It may produce all the various forms of exudates as the result of congestion set up by its presence. It may produce otitis media, meningitis, osteomyelitis, and serious suppurative disturbance

in the periosteum, the salivary glands, the thyroid, the kidney, the endocardium, etc.

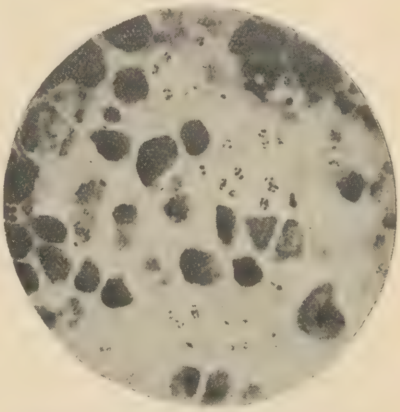
D. The *micrococcus tetragonus* grows in groups of four, enclosed in gelatinous capsules, at ordinary room-temperature, with or without oxygen; is ordinarily pathogenic for the smaller animals, and is found frequently in tubercular cavities in the lungs, less often, in connection with other cocci, in abscesses about the jaws and neck, into which it

FIG. 16.



Diplococci pneumoniæ (microc. lanceolati) in pus from peritoneal cavity; × 1000 (Fränkel and Pfeiffer).

FIG. 17.



Micrococcus tetragonus in splenic pulp; × 1000 (Fränkel and Pfeiffer).

seems to have gained entrance through the mouth. Suppurations produced by these organisms alone are prolonged, mild in character, not painful, but accompanied by much brawny induration of tissues.

E. The *micrococcus gonorrhœæ* or *gonococcus* is found constantly in the pus of true gonorrhœa, in many cases the pus being a pure culture of this organism. These cocci are always met with in pairs (biscuit-shaped), while their inclusion within the leucocytes or their attachment in or to epithelial cells is characteristic.

Unlike all other pyogenic cocci, these do not stain by Gram's method, being decolorized by iodine, by which fact they may be distinguished. They are cultivated with difficulty, and are known rather by their clinical effects than by their laboratory characteristics; are a strict human parasite, other animals, so far as known, being practically immune. The gonococcus may also produce abscesses, and may be carried to distant parts of the body, where its effects are most commonly noted as pyarthrosis, although endocarditis, pericarditis, pleurisy, etc. are known to be due to it, and fatal pyæmia has been produced in consequence. In some way, not always clear, it is probably the explanation of the *post-gonorrhœal arthritis* so often wrongly spoken of as gonorrhœal rheumatism.

F. *The Bacillus coli communis or Colon bacillus.*—This is an ordinary inhabitant of the intestinal canal; varies extremely in virulence and somewhat in morphological appearances; coagulates milk; is often associated with other organisms; migrates easily both along the alimentary canal and from it into the surrounding tissues or channels. It is a frequent disturbing element in the production of kidney and hepatic disease, as also in the production of appendicitis and perito-

nitis. Ordinarily its pyogenic properties are not virulent; occasionally, however, it becomes extremely virulent.

The colon bacillus is found at points widely separated from its natural home, and has been known, for instance, to produce abscess in the brain. The pus due to the presence of these organisms, either in pure culture or mixed, is usually characterized by an offensive fecal odor, which led to the attempt to separate the bacillus fœtidus as a distinct form.

The *bacillus pyogenes fœtidus* and the *bacillus lactis aërogenes*, as well as certain other forms occasionally met with in connection with disease, are now regarded as identical with the colon bacillus.

G. The *bacillus pyocyaneus*, a widely-distributed organism, often met with in the skin and outside of the body; a motile, liquefying bacillus, growing at ordinary temperatures, seldom met with alone, but occasionally producing pus without association with other organisms; it stains the discharges and dressings a characteristic bluish-green and imparts sometimes an offensive odor.

Suppuration caused by this bacillus is usually prolonged, but characterized by little constitutional disturbance. Is often found in enteric discharges. When, as it may, it produces general infection, it may cause hemorrhagic or gangrenous enteritis. The bacillus pyocyaneus is an organism quite tenacious of life, and one which it is sometimes difficult to completely get rid of. I have known patients to follow, one after another, in the same bed or the same corner of a room, in each of whose cases blue pus was a marked feature. It seemed very much as if infection hung around this particular locality, and as if the organisms were not disposed of by the ordinary process of disinfection.

Among other organisms which have been more or less identified with the obligate pyogenic bacteria, and yet which have scarcely found a prominent enough place to deserve more than mere mention here, are the *staphylococcus salivarius pyogenes*, the *micrococcus salivarius septicus*, the *micrococcus gingivæ pyogenes*, which have been found in saliva in the human mouth; the *streptococcus septicus liquefaciens*, found in the same cavity; and the *streptococcus coryzæ contagiosæ equorum*, met with in that disease in the horse known as *strangles*, where it is found in the pus.

Facultative Pyogenic Organisms—*i. e.* those which have the power of provoking suppuration, but which have other and more distinct pathogenic activities as well.

A. *Bacillus typhi abdominalis.*—This is found in many pus-foci, developing during or after typhoid fever. It is occasionally met with alone, though most of these abscesses are really mixed infections. It is most commonly met with in the bone or beneath the periosteum. Such abscesses are frequently met with in the ribs, and may not be noticed until months after the convalescence from the fever. The pus contained within them is not always typical in appearance, but may be unduly thin or unduly thick.

B. *Bacillus proteus.*—Under this name are included three distinct forms which were originally described by Hauser as distinct species, but which are now regarded as pleomorphic forms of the same organism. It is a motile bacillus, met with in decomposing animal and vegetable material, and occasionally found in the alimentary canal. It has been found to produce pus, especially in the peritoneal cavity and about the appendix. It may even cause general infection and peritonitis.

C. *Bacillus diphtheriæ.*—A non-motile bacillus, varying considerably in size and shape, changing the reaction in sweet bouillon from acid to alkaline; produces a most dangerous infective inflammation of exposed surfaces, with tenacious exudate amounting to a distinct membrane. As a part of its life-history it also produces a powerful toxalbumen, which is one of the most profound cell-

poisons known, the disintegration of the cell-constituents due to its action being rapid and pronounced. This will account for the sudden heart-failures which are so often reported in connection with the disease. The distinctive membranes may be produced on any abraded surface in any part of the body. Diphtheria of wounds is much more common on the European continent than at home. It is connected always with at least superficial necrosis, and sometimes with very extensive gangrene, even of the so-called hospital type. Most of the abscesses met with in diphtheritic cases are instances of mixed infection, although it is said that occasionally the pus may be almost a pure culture of the diphtheria bacilli. All the symptoms and disturbances of diphtheria can be produced by the toxalbumen except the membranes, which apparently require the presence of the bacilli to provoke the coagulation.

D. *Bacillus tetani.*—More will be said about this organism when considering Tetanus, and to that subject the reader is referred. The tetanus bacillus is occasionally found in pus which comes from the area through which the original infection was produced. But these bacilli do not travel to any distance in the human body, and are practically never found away from the area primarily involved. Under most of these circumstances the pus is the product of a mixed infection.

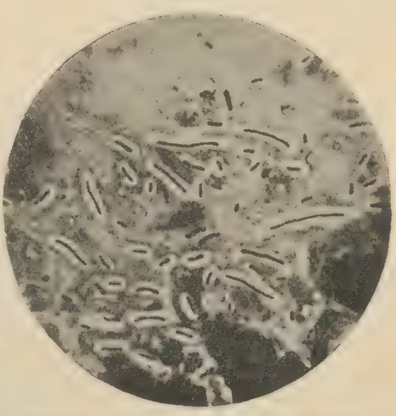
E. *Bacillus œdematis maligni.*—This, too, will be more fully considered under a different heading. (See Malignant Œdema.) It is a long, anaërobic bacillus, widely distributed in the soil and the fæces of animals. There is reason to think that this, like the tetanus bacillus, may occasionally lead to formation of pus.

F. *Bacillus tuberculosis.*—This organism likewise will receive fuller description in an ensuing chapter. (See Tuberculosis.) The pus of old cold abscesses, in which the more obligate pyogenic organisms have long since died out, usually still contains this organism in mildly virulent form. On the other hand, fresh suppurations occurring in connection with tubercular disease are mixed infections. There is reason to hold, however, that this organism is capable of producing pus even when none of these are present. For example, in that form of acute miliary tuberculosis which is occasionally met with as bone-abscess it may be found, for whose origin we naturally look to this organism.

G. *Bacillus anthracis.* (See Anthrax.)—This is one of the most malignant and resistant organisms known, being in the highest degree poisonous for the smaller animals, man being less susceptible. One of its characteristic lesions in the human body is a form of pustule commonly known as *malignant pustule,* the pus in which is usually a pure culture of this organism.

H. *Bacillus mallei.*—This is the organism which produces glanders in the lower animals and in man. That form of the disease which is commonly known as farcy, in which the infected nodules rapidly break down, is most likely to contain pus which shall be more or less a pure culture of this organism.

FIG. 18.



Friedländer's pneumococci, from sputum; × 1000 (Fränkel and Pfeiffer).

I. *Bacillus lepræ.*—This is the microorganism which produces leprosy and which closely resembles the tubercle bacillus. It is constantly and exclusively present in the lesions in leprosy, which are often of the suppurative type, the bacilli being enclosed within pus-cells, as well as found in the fluid surrounding them. Although suppuration in these cases may be in a large measure due to secondary infection, it is positive that the leprous bacilli deserve to be grouped in this place.

J. *The bacillus pneumoniæ of Friedländer* was at one time regarded as the cause of croupous pneumonia, which is now known to be due to the micrococcus lanceolatus. The Friedländer bacillus, however, is capable of producing broncho-pneumonia, and is occasionally met with in empyema, suppu-

rative meningitis, and inflammations about the naso-pharyngeal cavity, of which it is known to be an occasional inhabitant.

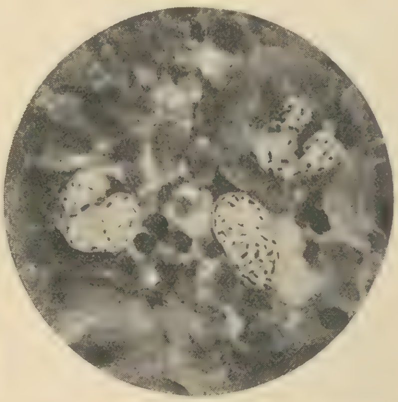
K. *The bacillus of influenza*, perhaps the smallest bacterium yet described, has been found in the purulent discharges from patients suffering from grippe. While the etiological relations of this bacillus to the surgical sequelæ of grippe (quite numerous, by the way) are not yet finally established, the organism is, nevertheless, of interest and importance to the surgeon.

L. *The Bacillus of Rhinoscleroma.*—A distinctive organism has been described for this disease and given this name. It has such wide morphological differences, however, that it is possible that it is only the bacillus of Friedländer above mentioned. At all events, an organism of this general character is constantly found in the thickened tissues from the nose in this disease. (*Vide* Fig. 20.)

FIG. 19.

Rhinoscleroma: infiltration of tissues about the nose (case reported by Dr. Wende, Buffalo).

FIG. 20.



Bacilli of rhinoscleroma; × 1000 (Fränkel and Pfeiffer).

M. *Bacillus septicæmiæ hæmorrhagicæ.*—This is known also as the bacillus of chicken cholera, of rabbit septicæmia, of swine-plague, and of deer-plague. It is probably also the same as the bacillus described by Davaine in 1872. It is found in the blood and œdematous fluids of affected animals, produces indol when grown in peptone solution, and retains vitality for a long time when not dried. Its most characteristic pathogenic activities are to cause swelling of the spleen and lymph-nodes, ecchymoses in mucous membranes, acute œdema at the point of inoculation, hemorrhages and degenerations in muscles, and pus in certain animals.

N. *The Bacillus of Bubonic Plague.*—This was recently discovered by Kitasato, and, in view of the recent ravages of the disease in the Orient, has assumed considerable importance. It grows upon most media, and is found in the blood, in the buboes, and in all the internal organs of patients suffering from this disease. The smaller animals are susceptible upon inoculation. Animals fed with inoculated foods die also, showing the possibility of infection through the intestine. When exposed to direct sunlight for a few hours the bacillus dies. The general expressions of the disease are those of hemorrhagic septicæmia and its consequences.

O. *The Bacillus of Rauschbrand.*—This is seldom, if ever, seen in this country. It is known in England as "the black-leg" or "quarter-evil." It is an anaërobic organism, frequently met with in cattle, which causes a peculiar emphysema of subcutaneous tissue, which spreads more deeply, and is followed by a copious exudate of dark serum with gas-formation. The smaller animals are not ordinarily inoculable; but, if to the culture-material used be added 20 per cent. of lactic acid, their insusceptibility is overcome and they succumb quickly to the disease. So also, as in the case of the tetanus bacillus, by addition of the bacillus prodigiosus or of proteus vulgaris the disease may be induced in otherwise insusceptible animals.

Fungi.

Besides the micro-organisms everywhere grouped as bacteria, there are other minute organisms which have also the power of engendering pus. One of these is the ray-fungus, known as the *actinomycis*, which causes the disease known as lumpy jaw or actinomycosis. Suppuration is always a concomitant of the advanced lesions of this disease, and, while it may be in many instances a mixed infection, it is not necessarily so. Moreover, the pus produced under these circumstances contains minute calcareous particles which are pathognomonic, and by which a diagnosis can sometimes be made off-hand.

Besides these fungi, others, belonging rather to the class of vegetable moulds, which are yet pathogenic for human beings, may be occasionally met with under these circumstances—for example, *the fungus of Madura-foot*, the *leptothrix*, and other moulds from the mouth, while the different varieties of *aspergillus* may be found in pus about the ear, or even in that from the brain.

Protozoa.

The protozoa also have the power occasionally of producing, if not absolute ideal pus, something so strongly resembling it that we may include them among the facultative pyogenic organisms. The best known of these protozoa are the *amœbæ* which are so often met with in the intestinal canal in certain countries, and which are occasionally met with in the United States, especially as the exciting causes of a peculiar type of dysentery often accompanied by abscess of the liver. In these abscesses the amœbæ are usually found, and no other organisms. Another group of the protozoa, known to biologists as the *coccidia*, are also capable of causing pus-formation, more particularly in some of the lower animals. Numerous other parasites, belonging higher in the animal kingdom, are undoubted exciters of pus-formation, though it is not necessary to lengthen the list beyond those already mentioned.

Clinical Characteristics of Pus from Different Agencies.

Staphylococcus.—Dirty white, moderately thick, with sour-paste odor.

Streptococcus.—Thin, white, often with shreds of tissue.

Colon Bacillus.—Thick, brownish, with fetid odor, or thin, dirty white, with thicker masses.

Micrococcus Lanceolatus.—Thin, watery, greenish, often copious.

Bacillus Pyocyaneus.—Distinctly green or blue in tint.

Bacillus Tuberculosis.—Thick, curdy, white paste, or thin, greenish, with small cheesy lumps or even with bone-spiculæ.

Actinomycis.—Thick, brownish white, with small firm nodules of yellow color.

Amœba Coli.—Thick brownish-red.

Bacterial Determination as an Indication in Treatment.

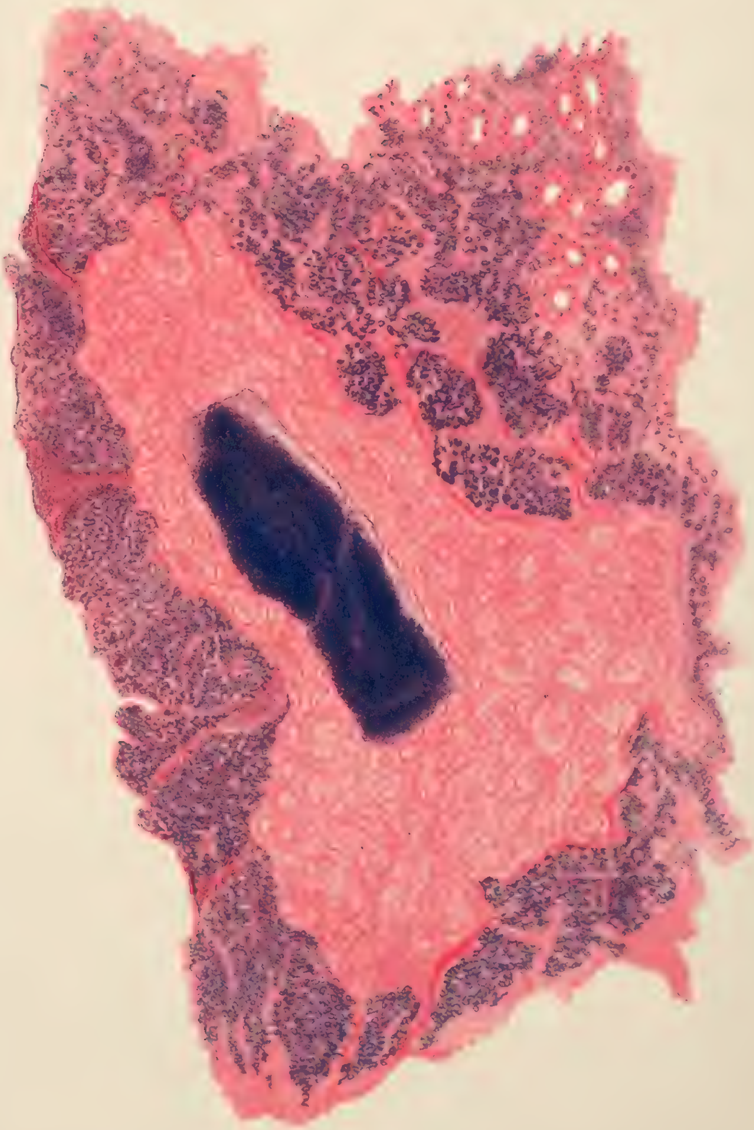
There is a practical side of great importance pertaining to the recognition of the nature of the infectious organism in many cases of suppuration and abscess. For instance, pus which is due to streptococcus invasion indicates a collection which should be freely evacuated and carefully drained. This is also true in essential respects of staphylococcus pus, particularly that due to the S. aureus. Putrid pus from any source calls for disinfection and free drainage, the former preferably perhaps by hydrogen dioxide. Pus which is due to the colon bacillus is not often extremely virulent, which accounts for so many cases of appendicitis recovering with or without operation. A collection of this pus calls for little more than mere drain-

age and opportunity for escape. Pus from a recognizable tubercular source may still contain living tubercle bacilli. This means either that the cavity whence it came should be completely destroyed and eradicated, or else that the margins of the incision or opening through which it has escaped should be so cauterized that infection of a fresh surface is impossible. The same is true of abscesses due to glanders bacilli and to certain cases of suppurating bubo following chancroid, where the whole course of events shows the virulent character of the organisms at fault.

Suppuration.

Although it may be possible to produce in certain laboratory experiments metamorphosed material which very closely simulates pus, or, in fact, by injection of chemical irritants, to sometimes quite faithfully imitate the suppurative processes, nevertheless, the student must be promptly brought face to face with the statement, to which for surgical purposes there is no practical exception, that **suppuration**—*i. e. formation of pus*—**is due to the presence in the tissues of the specific irritants already catalogued and described**, *and of the peculiar peptonizing or other biochemical changes which bacteria exert upon living animal cells.* **Coagulation-necrosis** is the term applied to the characteristic changes occurring in the tissue-cells when thus attacked, which may be summarized as a fading away of cell-outlines, diminution in reaction to reagents, and a sort of merging together of cells and intercellular substance. Coagulation-necrosis is not the sole result of bacterial activity, but may be brought about from other causes. Nevertheless, pyogenic bacteria do not exert their deleterious action upon the tissues without bringing about changes included under this term. In an area thus infected, as already described, leucocytes—*i. e.* phagocytes—are present in largely increased numbers for purposes already distinctly described. As we get nearer to the centre of activity phagocytes are more numerous than are cells, and intercellular barriers completely break down. Where bacteria are found in greatest numbers, there also occurs the greatest phagocytic activity, and there too will be found the characteristic evidence of suppuration—*i. e. pus.* As already indicated, the *polynuclear leucocytes* are most active of all in the process of defence. Where coagulation-necrosis is most marked there has been the greatest activity of conflict with the greatest death of cells. Around these areas bacteria and cells are found in indiscriminate arrangement. Tissue-vitality is impaired by intoxication of the cells by the excretory products of the bacteria—*i. e.* the so-called ptomaïnes, toxines, etc.—and their power of resistance is thus weakened. From the mechanical results of pressure tension around the centre of activity is increased; by which tension vitality is still more impaired and more rapid tissue-death occurs. Thus there occurs migration or burrowing of pus; or, to put it more clearly, the tissues break down in front of the advancing destruction, and always in the direction of least resistance. This is known as the *pointing of pus*, and this it is which brings it many times to the surface, and often in other and less desirable directions.

PLATE IV.



Abscess in Kidney of Rabbit after Intravenous Injection into an Ear-vein of Culture of Pyogenic Cocci. Dense mass of cocci surrounded by area of coagulation necrosis due to their toxic activity. Outside this a zone of phagocytes

Abscess.

An **abscess** is a circumscribed collection of pus. The term is used in contradistinction to *purulent infiltration*, in which the collection is by no means circumscribed, but is exceedingly diffuse and extends itself in various directions, the amount at any particular spot being almost inappreciable. Purulent infiltration is commonly regarded as much the more serious of the two conditions, since it is much harder for pus to safely escape under these circumstances than when it can all be evacuated through a single opening. The term **phlegmon** is one which is now generally used, both at home and abroad, to indicate a suppurative process usually of the general character of purulent infiltration rather than of abrupt abscess, but somewhat generally employed to cover both conditions. The adjective *phlegmonous* is coupled with the name of any of the other surgical infectious diseases to indicate that it is complicated by suppuration—*e. g.* phlegmonous erysipelas. **Pus** is a product of bacterial activity which is usually formed rapidly rather than slowly, and abscess-formation or phlegmonous activity of any kind is ordinarily a matter of but a few days.

In connection with this I would like to summarize the story of inflammation and suppuration, to paraphrase Sutton, and read it zoölogically, as though it were the story of a battle. The leucocytes (phagocytes) are the defending army, the vessels its lines of communication, the leucocytes being, in effect, the standing army maintained by every composite organism. When this body is invaded by bacteria or other irritants, information of the invasion is telegraphed by means of the vasomotor nerves, and leucocytes are pushed to the front, reinforcements being rapidly furnished, so that the standing army of white corpuscles may be increased to thirty or forty times the normal standard. In this conflict cells die, and often are eaten by their companions. Frequently the slaughter is so great that the tissues become burdened by the dead bodies of the soldiers in the form of pus, the activity of the cells being proven by the fact that their protoplasm often contains bacilli in various stages of destruction. These dead cells, like the corpses of soldiers who fall in battle, later become hurtful to the organism which, during their lives, it was their duty to protect, for they are fertile sources of septicæmia and pyæmia. This illustration may seem a little romantic, but is warranted by the facts.

Around the margin of the site of an acute abscess is formed a barrier, by condensation and cell-infiltration of the surrounding tissues. This is not a distinct wall nor membrane, yet, nevertheless, serves as a sanitary cordon to confine the mimic conflict within reasonable bounds. This is the zone of real inflammation; within it there are tissue-destruction and coagulation-necrosis. (*Vide* Plate IV.) By virtue of the peptonizing power of the pyogenic organisms the parts involved in this necrosis gradually liquefy, the intercellular substance dissolving first. It is this which in the main forms the fluid portion of the pus. Various tissues show widely differing resistance to this softening process. In true glands the interlobular septa seem to break down first, and in this way suppuration extends around the acini or

gland-lobules, and thus pus may contain masses of easily recognizable size. These masses are ordinarily known as *sloughs*.

It is by virtue of the so-called lymphoid cells, which are those principally involved in producing the barrier or boundary of the acute abscess as above described, that granulation-tissue is formed, which promptly takes up the effort of repair so soon as pus is evacuated. This boundary has no sharp limit, but shades off into healthy surrounding tissues.

Under the term "abscess" is ordinarily meant that which is more minutely described as *acute abscess*. Under certain circumstances, especially where they are produced by the facultative pyogenic organisms rather than the obligate, abscesses form much more slowly, and may be spoken of as *subacute*. These are terms used in contradistinction to the so-called *cold abscess*, which, although clinically bearing a certain resemblance to the acute, is in almost every pathological respect widely different from it. Cold abscesses will be considered at length under the head of Tuberculosis. It is possible to have an acute pyogenic infection of a cold abscess; in such case we have acute manifestations. *Gravitation-abscesses* are those where pus forming in one part tends to migrate, usually in the direction in which gravity would take it, extending into portions deeper or lower down. Perhaps the best illustration of this is the pointing of a psoas abscess below Poupart's ligament. *Metastatic abscesses* are those which are formed as the result of embolic processes, each one being in miniature a repetition of a lesion which has already occurred at some other part of the body. The underlying fact concerning metastatic abscesses is that the primary process has occurred in some other portion of the body, whence it has been distributed as above. These will be more fully considered in the chapter dealing with Pyæmia.

The characteristic product of all acute suppurative lesions is pus. This is an opaque fluid of creamy consistence and whitish or grayish appearance, varying somewhat in density, met with in amounts from a minute drop to collections of half a gallon or even more. Under ordinary circumstances it is odorless, and its reaction, either acid or alkaline, very faint. It is, like the blood, composed of a fluid and a solid portion. The solid portion consists of so-called *pus-corpuscles* and other débris of tissue, which will vary with the site of the disease and the parts involved. The source of the pus-corpuscles has already been cited at length, and the statement already several times made that they are in effect the bodies of phagocytes which have perished in the biochemical fight for existence of the parent organism. In them may frequently—almost always, in fact—be seen cocci or bacilli, which are also found in large quantities in the surrounding fluid. It is characteristic of certain micro-organisms to sustain peculiar relations to the pus-cells, which will be considered more at length in their appropriate place. Aside from these, there will be granular débris, the result of breaking-down leucocytes and other normal cells. When treated with acetic acid and various staining reagents, the pus-corpuscles are found to be multinucleated, which is a sign rather of degeneration than of proper cell-activity. Under the microscope, with fresh pus from an acute abscess, certain pus-cells will be seen to show amœboid movements. The characteristic pus-corpuscle is in reality an original polynuclear leucocyte.

Pus should be ordinarily without odor, but under certain circumstances it possesses an odor which will vary in character according to the source of the pus or the nature of its principal bacterial excitant. Pus from the upper end of the

alimentary canal frequently has the sour smell so characteristic of gastric contents; that from the neighborhood of the lower end, the characteristic fetid odor which is for the most part due to the action of the colon bacillus. Inasmuch as this colon bacillus is found in widely distant parts of the body, it may also give unpleasant odor to pus even from a brain-abscess. When the pus has become contaminated by any reason with the ordinary saprophytic organisms, it may smell like any other decomposing material. The older writers used to speak of this as *ichorous pus*, while *sanious pus* was supposed to be that more or less mixed with blood, undergoing ammoniacal decomposition or else strongly acid. Pus sometimes has a well-marked *blue* or *bluish-green tint*. This is due to the presence of the *bacillus pyocyaneus*, already described. An orange tint is sometimes given by the presence of hæmatoidin crystals, due to the original hemorrhagic character of the infected exudate. The former appearance indicates usually a discouragingly slow course to the suppurative lesion, while the latter has been regarded by some as affording an unfavorable prognosis. Distinctly red pus, whose tint is due to the presence of a bacillus giving bright-red cultures on blood-serum, has been noted in other instances. This can readily be distinguished from blood, because upon dressings it does not change color.

Surgeons of ordinary experience are accustomed to allow a certain rather indefinite length of time between the first sign of impending suppuration and the formation of pus, in those parts of the body where the course of events can be reasonably well distinguished. This is measured ordinarily by an interval of from sixty to one hundred hours. Under certain circumstances, however, suppuration takes place with almost fulminating rapidity, and this is particularly true in appendicitis, meningitis, and in the disease known as malignant œdema. Extensive coagulation-necrosis occurs very early, and the patient may even die before pus has time to form.

Pus may form quite superficially, when we speak of it as a subcutaneous suppuration, in which case there is a minimum of pain, because tension is not great and because the distance to the surface is short. Collections which form beneath the fasciæ, especially the deeper fasciæ of the limbs and trunk, give rise to much more extensive disturbance, both locally and generally, and frequently do not point for many days, or, instead of pointing, burrow deeply and find their outlet at some undesirable point. These are known as *subfascial* collections. *Subperiosteal* abscesses give rise to still more pain, because of the unyielding character of their limiting structures, and the symptoms caused by them are often very acute and very distressing.

An illustration of the pain and disaster which may follow deep suppuration may also be seen in the ordinary panaritium or bone-felon, where the path of infection is from without, but the destructive lesion is confined within absolutely unyielding tissues, at least at first. Along certain tissues infection spreads with amazing rapidity. This is particularly true of the delicate areolar tissue met with between tendons and tendon-sheaths, and the infectious process may follow this tissue wherever it shall lead, even along complex courses.

The question is often raised, *Can pus be resorbed?* There is no question but what under many circumstances small amounts of pus are disposed of by phagocytic activity, and the disappearance of purulent infiltration under the influence of favoring remedies, or even when left alone, is not infrequently noted. True pus-resorption is entirely a question of phagocytic possibilities, and can only occur in very limited degree as a result upon which it is not safe to count, and which is capable of encouragement only up to a certain point.

One inevitable law seems to govern collections of pus, and that is,

that when they *advance* or migrate in any direction it is always in that of *least resistance*. This causes it to take peculiar and sometimes disastrous courses, but it is a law which is virtually never violated. It leads, for instance, to the bursting of abscesses into the brain, into the pleural cavity, into the peritoneal cavity, the bowel, and elsewhere; it leads to a condition where pus may travel slowly along a path even a foot or more in length, rather than come directly to the surface, a distance of perhaps an inch, and affords one of the best reasons for early operative interference in order that the disastrous effects of burrowing may be obviated. When the collection of pus is limited to a drop or a fraction thereof, the little abscess is usually spoken of as a *furuncle*, especially when in the skin. The average "boil" of the layman is a subcutaneous or subfascial abscess near the surface. When the infiltration is pronounced, and when there has been more or less extensive destruction of tissue, with perhaps formation of numerous outlets for the desired escape of pus and detritus, we have what is known as a *carbuncle;* all of which will be of treated in Chapter XXVIII. In certain peculiar conditions small superficial furuncles or boils form, sometimes in great numbers and almost synchronously, or, as it were, in crops. This condition is spoken of as *general furunculosis*.

Signs and Symptoms of Abscesses.—The appearances by which the presence of pus may be suspected or detected are those of congestion and hyperæmia, more or less abruptly circumscribed and markedly accentuated. Along with these there is more or less œdema or œdematous infiltration of the skin and overlying tissue, which permits of that peculiar appearance known as "pitting on pressure." Often, too, there is a distinctly œdematous swelling of the parts, especially around the margin, with brawny infiltration of the centre of the infected area. Numerous vesicles occasionally are noted upon the skin, which may be filled with reddish serum. As softening and actual pus-formation occur, we get a condition which to the palpating fingers gives the characteristic sensation known as *fluctuation*. Fluctuation ordinarily simply points out the presence of fluid beneath; but when in an area marked as thus described fluctuation is noted, it practically always means the presence of pus beneath. It is best detected by manipulating in a direction parallel to and concentric with the axis of the limb or part. The pain is also significant in most instances: patients speak of it, ordinarily, as having an intense and throbbing character. Along with these local signs occur often more or less reliable symptoms indicating some degree of septic intoxication—*i. e.* pyrexia, chills, malaise, sweats, etc.—which are always corroborative indications, their intensity being a reasonably correct index of the severity and gravity of the local infection.

It is but seldom that a superficial collection of pus can ever be mistaken for anything else. In small and superficial abscesses (boils, furuncles) as pus approaches the superficial layer (epidermis) of the skin it may often be discovered through its thin covering. In deeper lesions there is often room for honest doubt, even on the part of the most experienced. The measure now usually resorted to for purposes of diagnosis and exact recognition is the exploring or aspirating needle. The old exploring needle was one of good size, having a groove along which, after introduction, pus might pass. Since the common and every-day use of the hypodermic syringe, a small aspirating needle attached to

the ordinary syringe is now the measure commonly adopted. Such a needle may be introduced into the brain, into the liver, or into almost any and every soft tissue without danger, and if properly manipulated is almost sure to facilitate detection of pus. Exploration done with either of these means and for this purpose should always be conducted as an aseptic, even if a minor operation, in order that no extra infection may be added from without. The skin should be carefully washed, the needle sterilized, etc.

It is well known by observations of writers, although to-day too often forgotten, that repeated punctures of this kind, either with the needle or with the fine-bladed knife, not only give information as above described, but have an antiphlogistic effect; that is, in some indirect way they seem to check the process and bring about a more rapid resorption or disposition of inflammatory products than would otherwise take place. The *antiphlogistic touch* of the knife, then, is a measure which Pancoast and other eminent surgeons of the previous generation have taught us, and constitutes a remedial measure never to be despised. The same may be said for antiseptic exploration of deep lesions, as in the liver and elsewhere.

It is often good surgery to resort to the knife either for the above purpose or in order that by a longer incision or by the opening of the cavity deep exploration may be made. Such explorations are usually of benefit even though one fail to find a circumscribed collection of pus, since by relief of tension and local abstraction of blood they act in a revulsive way and do much good. Acting upon the same principle, one may use the trephine or the bone-chisel for the purpose of opening the cranium and exploring for deep collections of pus, or of opening into the medullary canal of the long bones and hunting there for that which we have reason, from external appearances, to suspect.

Treatment.—So soon as suppuration threatens, one should adopt speedy measures, either for the purpose of bringing about resorption, if possible, or of favoring and hastening suppuration. In theory antiseptic applications are demanded; in practice they are sometimes of benefit. These may consist of mere soothing applications, like the lead-and-opium wash of our forefathers, or some other wet or dry astringent applied upon the surface, or they may consist of cold applications, which by their astringent action shall limit the amount of exudate and possibly prevent its further infection. Or, as is the customary practice everywhere, one may take advantage of the well-known properties of moist heat, and by the application of hot poultices or fomentations may encourage exudation, but particularly hasten superficial breaking down, and thus hurry that desirable time when the abscess shall point, or at least shall come near enough to the surface to plainly show that its contents are pus, and to permit of easy evacuation. Such local applications, therefore, give relief from pain and hasten favorably the suppurative process. In cases of phlegmonous infiltration I favor, above all other measures, the application of an ointment composed of resorcin 5, ichthyol 10, mercurial ointment 35, and lanolin 50 parts. Under the influence of this antiseptic and sorbefacient preparation, and of moist heat, one may see many phlegmonous infiltrations assume a kindlier type, and may even perhaps secure the actual resorption of pus.

Finally, in almost every case the time comes when pus must be evacuated. Here, again, the universal rule may be laid down to which there are practically no exceptions. This needs to be deeply stamped on the mind of every student and young practitioner. It

is—that *pus left to itself will do more harm than will the knife of the surgeon if judiciously used for its evacuation.* All action take in accordance with this rule may be considered wise and timely. The operation of evacuation may at one time be a mere puncture, or possibly the aspirator needle alone will be enough; at other times it requires extensive and careful dissection and entails no little responsibility. This is particularly true in such deep-seated suppurations as those around the appendix and in the brain, while in deep-seated bone-lesions of this character the extensive use of the bone-chisel or the cutting forceps will be called for. But the rule holds good, no matter where the pus may be, and so long as good judgment be shown in the operative procedure nothing but good can come from recognition of this law. After the evacuation of pus the cavity should be cleansed so far as circumstances permit, and disinfected with hydrogen dioxide, perhaps even with caustic pyrozone, or, if these be not at hand, with other suitable antiseptic solutions.

Ordinary judgment should be manifested in evacuating every abscess, in order that opening be made at that point which in the common position of the body shall be most favorable to drainage by mere gravity alone. If circumstances compel opening where advantage cannot be taken of gravity, then one or more *counter-openings* must needs also be made, these at points to be selected where drainage may be best effected, and at the same time where anatomical conditions do not make it injudicious to incise. Drainage must, furthermore, be favored by the introduction of drainage tubing or of other aids, such as gauze, strands of catgut, bundles of horse-hair, etc. Finally, a dressing must be applied which shall be both protective and absorbent, and in quantity sufficient to make compression of the walls of the abscess-cavity—not sufficient to obstruct drainage, but enough to favor prompt adhesion of surfaces, which by speedy granulation shall ensure prompt healing.

Abscesses in peculiar locations call sometimes for distinctive methods of attack. Thus, a suppurating cyst in the abdominal cavity is often first sewn to the margin of the abdominal incision before it be evacuated—this when complete extirpation of the same without opening is impracticable. This is known as Volkmann's method—is applicable generally to abscesses in the liver whose walls have not become adherent to the abdominal parietes, and to gangrenous abscesses in the lung where, again, the adhesions have not yet shut off possible access to the pleural cavity. Or gauze is packed in and left *in situ* for twenty-four to forty-eight hours, until adhesions by exudates have formed.

Occasionally an abscess is so located as to make it quite impossible to open it at its lowest portion or drain it. In these cases it is possible sometimes to take advantage of the physical properties of glycerin, which has higher specific gravity than pus. By keeping such a cavity reasonably well filled with boroglyceride, for instance, pus as it may form will be floated to the surface and more easily gotten rid of, while at the same time the cavity itself will be kept much more clean and in a much more desirable condition.

Certain abscesses are so located in proximity to large vessels or dangerous anatomical regions that the greatest care must needs be exercised in opening them. Here much better than the bold incision is the careful dissection made under an anæsthetic. This may be true of abscesses in the neck; it certainly is true of those around the appendix; for example, where the general peritoneal cavity is only shut off by more or less delicate adhesions, and where one must literally feel his way with great precaution lest adhesions be torn and the previously protected cavity be infected. At other times, especially in abdominal

abscesses, it is necessary to pack sponges or absorbent gauze in and about the parts in such a way that any fluid which may inadvertently or necessarily escape shall be caught by these dressings and thus kept out of harm's way.

Accompanying Disturbances.—The disturbance of function which accompanies all congestion and exudation, whether provoked by specific irritants or not, has already been alluded to; but in cases of surgical infections, especially those which produce local suppuration, disturbance of function is much greater, while there are other more widespread disturbances which sometimes constitute the worst feature of these cases. The *presence of pus* is often indicated, especially when deeply seated, by one or more *chills*, and the occurrence of a chill is always marked by *pyrexia* to varying degree. It is correct to say that the chill is an expression of a general septic disturbance; but it is necessary also not to forget that general septic disturbance is a frequent accompaniment of pus which is not promptly evacuated so soon as formed. Moreover, in certain cases suppuration and septic infection seem to occur synchronously, one being local, the other general.

Of the exact causes which lead to elevation of temperature this is hardly the place to speak—for one reason, because the theories of fever are so numerous, and because investigators are yet far from being united in their opinions. The conditions underlying heat-regulation are as yet not well understood. It is characteristic of fever, however, that the respiration-rate is increased as well as temperature elevated. It is characteristic also of the contradictions afforded in disease that, in spite of the intense chilly sensations, body-temperature may be much elevated. The probable explanation of pyrexia is the presence of pyrogenic substances within the circulation; but an expression of this kind must necessarily be too vague to be corroborated by any very exact statements without going, even in detail, into a large amount of experimental study, for which this is not the place. At all events, pyrexia is not purely nor necessarily a disastrous condition, but may be in no small degree conservative, since deleterious substances may thus be burned up or temperature raised too high for pathogenic micro-organisms to flourish. When dealing with sepsis the question of temperature and its characteristic alterations will be more fully discussed.

The other general disturbance, or perhaps the most widespread general disturbance with which suppuration is so often complicated, is *septic infection*. In fact, it may be questioned whether pyrexia is not really an expression of this condition. With the general statement that any collection of pus, no matter how small, may cause recognizable signs of septic infection, and that, on the other hand, large collections may be formed without serious septic symptoms—in other words, with the statement that suppuration and expressions of septic infection may be blended in almost every conceivable way—the further consideration of sepsis as a distinct condition will be relegated to another chapter.

It is important to summarize what may become of pus when once it has formed and is not promptly evacuated. Without going freely into the subject, pus may when long present be—

A. *Absorbed.*

B. *Encapsulated.*

C. *Undergo various degenerations or chemical alterations.*

A. The possibility of the *absorption of pus*, or, what is equivalent to it, its spontaneous disappearance, has already been mentioned. While it does not usually take this course, it may thus disappear, as, for instance, in the anterior

chamber of the eye in cases of *hypopyon*, or in various other localities, particularly when present only in small amounts. The absorption of pus is purely a matter, so far as we know, of phagocytic activity plus the power of the tissues to take up various fluids.

B. *Encapsulation.*—This only occurs when pus has been present for some time and when the virulence of the pyogenic organisms is not intense. We may get encapsulation of pus in any part of the body, the most typical illustration naturally being within the bones. Around the purulent focus, as around any other irritating foreign body, the capsule is formed by condensation of surrounding tissue. This is, in fact, the way in which most cold abscesses with their limiting membranes are produced, those produced by tubercle bacilli having ordinarily relatively slight irritating properties. Inasmuch, then, as the biological activity in such a focus is small, there is time for such encapsulation; while by the membrane thus formed, or the sanitary cordon as I have already spoken of it, protection is afforded to the surrounding tissues. In such a collection fresh infection may incite acute disturbances again, and many abscesses which thus lie latent for considerable lengths of time are fanned, as it were, into a conflagration, when a new and acute inflammation is produced.

C. Of the various *metamorphoses* and *chemical changes* that occur in that which was originally pus, the caseous and the calcific are the most common. These also are connected largely with the tubercular process, although calcareous particles are met with in the pus of actinomycosis. Under their respective heads these degenerations will be more particularly described.

Certain particular names have been given to collections of pus in particular localities or under peculiar circumstances. A collection of pus in the anterior chamber of the eye is known as *hypopyon;* when in any pre-existing cavity, it is known as *empyema* of that cavity, the *distinction between empyema and abscess* being that "abscess" means a circumscribed collection where previously there was no cavity, while "empyema" implies a normal cavity, without respect to size or location, filled with this abnormal fluid. By common consent, without other authority than common usage, the term *empyema*, when not used in connection with some particular cavity, is understood to refer to a collection of pus in the pleural cavity. Other names are also used which are particulate and distinctive; in these the prefix *pyo-* is used, while the suffix indicates the part involved: thus we have *pyothorax, pyopericardium, pyarthrosis,* etc.

Sinus and Fistula.

These are terms applied to more or less *tubular channels abnormally connecting various parts of the body, or connecting some cavity with the surface of the body in a way anatomically quite abnormal.* Or they may be regarded as *tubular ulcers*, or ulcerated tunnels, connecting as above. A more exact distinction between the two terms would imply that a *sinus* connects the surface with some deeper portion where a cavity is not normally present—*i. e.* with a focus of disease; whereas a *fistula* properly refers to a tubular passage connecting natural or pre-existing cavities in an abnormal manner. Thus, we speak of buccal, rectal, vesico-vaginal fistulæ, etc., whereas a passage leading down to an old abscess or to a focus of disease in bone, for instance, is properly spoken of as a sinus. It is possible for the margins of a fistula to become more or less cicatrized and to cease to be ulcerous; whereas the entire track of a sinus is practically a continuous ulcer, only tubular in arrangement.

Causes.—A. *Congenital.*—There are numerous points about the body where, as the result of arrest of development or failure to grow, fistulous passages which are comprised within the normal fœtal arrangements, but which should close later, either before or at birth, fail to do so. In this way we get, for example, congenital fistulæ of the neck, persistent urachus, persistent omphalo-mesenteric duct, etc. These are in no sense primarily connected with diseased conditions, but may become so secondarily.

B. *Pre-existing abscess with unhealed channel of escape—e. g.* rectal, fecal, and other fistulæ and sinuses which connect with tubercular foci in any part of the body.

C. *Previous traumatic or other destruction of normal tissues*, as, *e. g.*, vesico-vaginal fistulæ due to tissue-death from pressure, buccal fistulæ from gangrene of the cheek, as in noma.

D. *Foreign bodies*—bullets, ligatures, etc.—which prove irritating or infectious enough to prevent absolute healing. More or less tortuous sinuses will almost always be found leading down to the irritating material.

E. *The presence of necrosed or necrotic material*, as, for example, a sequestrum in bone, which is usually evidenced by the presence of one or more sinuses.

Sinuses and fistulæ may be single or multiple; may be direct or very sinuous or tortuous in their course; may be short or long, even, in rare cases, up to twenty-four inches or more. The appearance of the opening of a sinus will often be an indication as to the character of the diseased condition down to which it leads. In nearly all forms of deep tubercular trouble, especially of bone, the mouth of the sinus is surrounded by a little crown of fungous, often œdematous granulations, which are frequently arranged in an almost valve-like way, not preventing escape of fluid from within, but often making it difficult to introduce a sound or irrigator nozzle from without. The discharge from these openings will depend entirely upon circumstances. Accordingly, it may be saliva, gastric juice, fecal matter, urine, pus, pyoid material, etc., the character of the same depending upon its location and cause.

Treatment.—If the determining cause be still acting, the treatment is practically summed up in the advice to remove the cause. Consequently, when the sinus leads down to diseased bone or other dead or dying tissue, the complete evacuation of the cavity is necessary before the sinus may heal. If the cause be a foreign body, its removal should be at once insisted upon.

Fistulæ of congenital origin and those which connect two normal cavities of the human body are usually due to a cause which has ceased to act. Consequently, one here endeavors solely to atone for the result. One may acquaint himself with the direction and, in a general way, with the course of a sinus by the use of a probe curved to suit the case and manipulated by a gentle hand, force never being required. Or sometimes, when the silver instrument fails to pass, a flexible bougie or catheter may be introduced. Information is thus gained as to the direction and extent. This information, however, is of less value than is ordinarily esteemed, since the character of the passage can be for the most part judged by the appearance of the discharges. With sinuses of recent origin leading down to recent suppurative foci it may be enough to enlarge the opening and to wash out thoroughly

the cavity as whose exit it serves. If, as sometimes happens, a particle of gauze, tube, or sponge have been left therein, its removal is probably all that is necessary to secure prompt healing. In cases of longer standing it is good practice often to inject antiseptic and stimulating substances, or even to cauterize the interior by means of strong solutions or by means of zinc chloride or silver nitrate melted upon the end of a probe. The *chronic* sinus, as well as the chronic rectal fistula, is almost invariably an expression of *local tubercular disease*. Accordingly, these passages will be found lined with the same dense fungating membrane which lines a cold abscess-cavity—the membrane, protective in its purpose, to which I have given the name *pyophylactic*. Whenever such tissue and such membrane are met with, they should both be extirpated as thoroughly as possible, since in this way only can absolute eradication of the tubercular infection be relied upon. After such complete excision—which means usually laying open the entire sinus—the parts may perhaps be brought together with sutures (this, at least, is usually possible about the rectum) in such a way as to secure primary union; otherwise, the whole sinus, as well as the cavity to which it has led, must heal by the granulating process, both being kept packed with gauze or some other desirable foreign body which shall act as an irritant, thereby provoking more rapid formation of granulation-tissue. When it is necessary thus to pack a cavity, or when it is desired to keep its upper exit open lest it heal before the lower part, ordinary white beeswax, as suggested by Gunn, makes a very serviceable material. This can be moulded in hot water to fit the cavity, can be tunnelled or bored for drainage, can be diminished in size as the cavity heals, and is absolutely non-absorbent.

Finally, there are numerous plastic methods which have been resorted to in various parts of the body, most of which are made to comprise, first, the absolute eradication of the diseased tract, and, later, the closure of the wound, thus made, by transplantation or sliding of flaps or any other plastic expedient which may be considered best. These, as well as the special treatment made necessary for particular forms of sinus and fistula, will be dealt with more at length under the proper headings in Volume II.

CHAPTER IV.

ULCER AND ULCERATION.

BY ROSWELL PARK, M. D.

THE term **ulcer** pertains to surfaces, and should be defined as **a surface which is or ought to be granulating**—*i. e. healing.*

While an ulcer may be the result of what is known as ulceration, it is by no means necessarily so, the term *ulceration* being one of very loose significance and applied to many different processes. For our present purposes the idea underlying ulceration is *infection*, and, when limited to its proper significance, the term should never be used for a process in which infection and consequent breaking-down of tissue do not virtually comprise the whole process. In this regard, therefore, it is to be abruptly distinguished from certain disappearances of tissue already alluded to under the head of Atrophy or Interstitial Absorption. It is therefore not correct to say that the sternum ulcerates away, making room for a growing aortic aneurism, the question of infection not here being raised. These distinctions should be accurately maintained and constantly borne in mind.

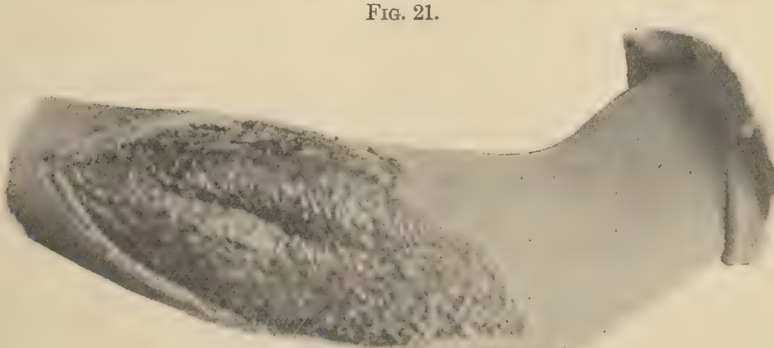
ULCERS.

The causes of ulcers may be—

A. *Traumatic;*
B. *Local;* or,
C. *Constitutional.*

A. *Traumatic.*—This would include all those surfaces which are

FIG. 21.



Recent traumatic ulcer of arm.

granulating and healing more or less rapidly, or are displaying, in other words, a kindly disposition toward healing, and which may have been originally produced by *wounds, burns, frost-bites, etc.* These include also those ulcers which are due to *pressure*, as from splints, bandages,

various orthopædic apparatus, or from *external friction.* Ulcers which form around *foreign bodies* may also be included under this head, their essential cause being traumatic.

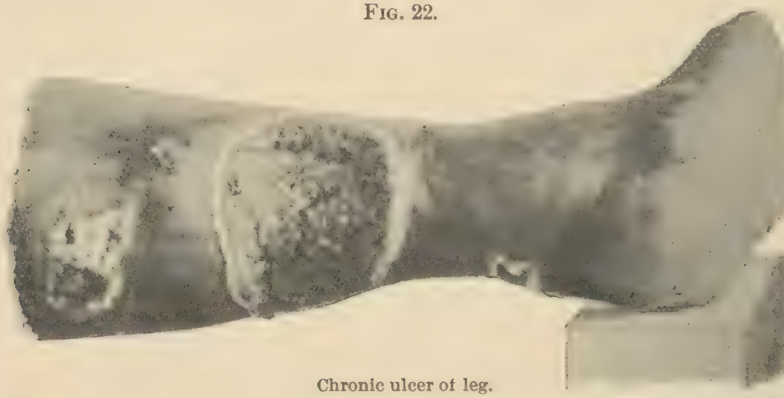
This should include also destruction of the surface by various *chemical agencies*, such as strong caustics; also the consequences of intense *heat* or *cold*, including particularly burns and frost-bites.

B. *Local.*—1. Among local causes may be mentioned *local infections* with tissue-death in consequence, such as occur in tuberculous, leprous, syphilitic, and other specific manifestations where surfaces are involved.

2. *Tumors*, either benign or malignant, whose blood-supply is cut off and whose surface is thereby predisposed to infection.

3. *Perverted surface-nutrition*, such as is most commonly met with, for example, in connection with varicose veins of the extremities, where,

Fig. 22.



Chronic ulcer of leg.

aside from any perverted trophoneurotic influence, there is stagnation of blood, saturation of tissues with serum, and final leakage of the same, even to the surface. In other words, a passive hyperæmia leads here to œdema, perversion of nutrition, failure to repair trifling surface-injury, and a commencing ulcer is the consequence.

4. So-called *pressure-sores* or *bed-sores*, which in some cases may be regarded as having a traumatic origin, but which, nevertheless, would not occur from purely traumatic influences without predisposing tissue-changes. The bed-sore is probably the best illustration of this. Simple ulcer is known as bed-sore, while a sloughing ulcer of this kind is frequently alluded to as *decubitus*. Such ulcers are usually found over those regions of the body made most prominent by bony projections, upon which undue pressure is made when debilitated patients have lain for a long time in bed.

5. Ulcer is the frequent result of numerous *skin diseases*, into whose etiology as yet bacteria have not been introduced—*e. g.* pemphigus, eczema, etc.

6. Ulcer is the occasional result of *embolic* or other *disturbance* of the principal artery of the part, by which nutrition is cut off and tissue-death results.

7. *Bites of insects* or other *parasites* or of noxious animals frequently lead to ulceration.

8. Certain more specific forms of ulcer are described by some writers, apparently with more or less reason, among them being *chancroid, perforating ulcer of the foot,* etc. Chancroid will be found described in Volume II. Perforating ulcer of the foot is a circumscribed circular ulcer with thickened edges, often nearly concealed by overhanging skin. It may be found in any part of the sole of the foot, but is most common near the first joint of the great toe. The borders of the ulcer are usually anæsthetic. By some it is closely associated with trophic nerve-disturbance; by others it is regarded as having a specific etiology of its own. The probability, however, is that it is simply a subvariety of pressure-sore.

C. *Constitutional.*—1. Ulcers are frequently met with in certain constitutional conditions which are characterized by tendency to local manifestation at points of least resistance. Among these should be mentioned *scurvy.*

2. There are ulcers of apparently distinctive *trophoneurotic* origin, of which that mentioned above as B, 8—perforating ulcer of the foot—may possibly be one. These notoriously accompany certain nervous disorders of central origin, prominent among which are locomotor ataxia and tabetic disease of all forms.

3. Ulcers are produced sometimes as the result of *specific* or selective *action of certain drugs,* among them mercury and phosphorus being the most prominent. These manifestations are met with in the mouth most commonly, and may perhaps be regarded as infections at points of least resistance. Nevertheless, they are commonly associated with the tendency of these drugs.

4. There are many constitutional conditions in which vitality is so lowered that a special liability to ulcer—*i. e.* infection and production of ulcer at many points—is noted. It is well, however, to mention that the common diseases in which this tendency is most often noted are typhoid, diphtheria, diabetes, and syphilis.

With this summary of the common causes of ulcer it should be again insisted upon that ulcers may be due to direct consequence of traumatic loss of substance or to the process of ulceration—*i. e.* as a consequence of previous infection, or as permitted by trophoneurotic disturbance and ischæmia. In this connection also ulceration should be spoken of as a process of *molecular death,* in which cells die successively and more slowly, as *distinguished from gangrene,* in which there is simultaneous death of large aggregations of cells, by which a slough or its equivalent is produced.

Ulcers are spoken of as *healthy* when the process of granulation is proceeding with average rapidity; *indolent,* when the reverse obtains; *sloughing,* when there is actual visible tissue-death in connection with the ulcerative process; *phagedenic,* when the gangrenous tendency is well marked and the process exceedingly rapid; *irritable or erethistic,* when the surface is exquisitely sensitive; *hemorrhagic,* when bleeding easily; *fungous or fungoid,* when the granulations have risen above the surface and are being manufactured at altogether too rapid a rate.

The best examples of the indolent ulcer are seen in connection with varicose veins of the extremities; of the phagedenic ulcer, in certain cases of chancroid; of the irritable ulcer, in ulceration of the cornea, where the pain and photophobia are intense; or in fissured ulcer of the anus, where the pain and sphincter spasm are sometimes agonizing.

Ulcers are described according to their *shape* as *regular* or *irregular*; as *fissured*, when they extend more or less deeply and abruptly into the

FIG. 23.

Varicose ulcer of leg, with lymphœdema (Dr. Holloway).

surface involved; as *fistulous*, when they have a tubular arrangement; as *rodent*, when they spare nothing in their course.

The *borders* of ulcers are described as *healthy*, *indurated*, *tumid*, *œdematous*, *undermined*, *livid*, *inflamed*, etc., these adjectives explaining themselves.

The *surfaces* of ulcers are described as *healthy* when they have normal color and appearance, *inflamed*, *excavated*, *covered with sloughs*, *callous*, etc. The *callous* ulcer is one which exhibits little change from month to month; its surface is dirty, and its secretion thin and muco-purulent. It is usually sunk considerably below the surrounding level, while its border is firm and nodular. The best examples of this form are those accompanying varicose veins.

In size or area ulcers may vary from the slightest local destruction of tissue to an area covering an entire limb or a large part of the trunk of the body. In depth also they vary within lesser limits, while an external ulcer may connect with some deep lesion by means of a tubular passage or *sinus*. It thus appears that the term ulcer may be applied to the result of a natural effort to repair loss of substance without intro-

ducing the element of disease, or that it may be the consequence of local infection with local tissue-disaster.

The character of the material discharged from an ulcer will vary much according to the category in which it belongs. The healthy, healing or granulating surface, often spoken of as ulcer, discharges a material in gross appearances much resembling pus from an acute abscess. In consistency it is the same, and in color and other appearances. Nevertheless, its origin is essentially distinct. This material represents simply the waste of reparative material sent up to the surface for the purpose of hurrying the process. Its fluid, like that of pus, comes from the serum of the blood; its corpuscular elements, like those of pus, are leucocytes or wandering tissue-cells, which have been furnished in great numbers—in fact, in excess. As it comes to the surface —or as, rather, it is rejected from the surface, being superfluous in amount—it is quite likely to become contaminated with bacteria by contact infection, and consequently may be seen under the microscope to contain various micro-organisms. This contamination has been final, however accidental and irrelevant. This material is *not pus;* has no infectious properties, except those which may accidentally be conveyed to it; represents no warfare of cells, only excess of supply or over-demand; and should be spoken of as pyoid or puruloid material, and never confused with pus. In amount it will vary according to the activity of the reparative endeavor, and somewhat according to the amount of irritation of the surface by dressings which may be applied. If a granulating surface be absolutely protected from possibility of contact-infection, it will never contain micro-organisms; while this *pyoid*, if allowed to remain too long, especially when infection is permitted, may decompose and become irritating, and is a material to be gently dislodged by a spray or an irrigating stream with each dressing, which dressing should be made once in twenty-four to sixty hours.

Material similar to this is met with often in drainage-tubes after the second or third day in instances where an absolutely aseptic course has been maintained. It is material of exactly the same character, due to essentially the same causes, will usually be found free from micro-organisms, will be gelatinous or coagulable to a degree permitting partial or complete occlusion of the drainage-tube, but has absolutely no infectious properties. This also, originating under parallel circumstances, may be spoken of as pyoid or puruloid material.

From ulcers having local infections as their primary causes discharges may come containing in themselves the specific irritants which may prove infectious to other points—which, in other words, may be auto-inoculable or hetero-inoculable. Such discharges, for instance, come from tuberculous, leprous, and syphilitic ulcers, and those of glanders and some other rarer diseases. Again, from sloughing and gangrenous ulcers will come yet other kinds of material containing bacteria of putrefaction in large numbers, having unpleasant odor, being blood-stained, or marked by other characteristics according to circumstances.

Processes of Repair.

An ulcer having been defined as a surface which is or ought to be granulating, it becomes necessary to define the granulation process and to show how healing is thereby achieved. Granulation-tissue is a name applied to a new and temporary tissue of embryonic type, which acts as a scaffolding or temporary structure, permitting the construction of more permanent tissue. It is produced entirely by the activity of

cells, which are the single and polynucleated leucocytes and the wandering cells already so often mentioned. They are frequently known as *embryonal cells* when performing this function; sometimes as *formative cells.* They have a distinct nucleus, which stains readily, and, having this resemblance to epithelial cells, they are often spoken of as *epithelioid cells*—sometimes as *fibroblasts*, because they may later assume the dignity of connective-tissue cells. They assume a multitude of shapes. In a way not yet sufficiently described, between these cells as they are drawn toward the point at which they are most needed, perhaps by chemotactic activity, there appears an *intercellular substance*, which later becomes fibrillated. As these fibres develop the remaining cells become entangled between them, and we have in this way a new connective tissue formed of cells of originally mesoblastic origin. Of such tissue the solid part of granulation-tissue is built. It is necessary to emphasize that this tissue is essentially different from the epithelium which it is expected will subsequently cover it. If a normal granulating surface be scanned with a magnifying glass of small magnifying power, it will be seen to consist of numerous minute projections, each of which is known as a granulation, and which consists of the tissue above described formed as a minute eminence around a budding capillary blood-vessel, from which a little projection has occurred upon the exposed surface. This capillary bud is the result of karyokinetic activity on the part of the endothelium—namely, the hypoblastic cells of which it is essentially composed. In each of these cells, under certain circumstances, the karyokinetic threads already spoken of develop and become loosely coiled, while the chromatin in the nucleus increases in amount and the nucleolus disappears. The chromatin threads become thicker, arrange themselves equatorially around the poles of the nucleus, and gradually turn so as to point toward it, while a new membrane forms around each separate coil, and two nuclei are thus made out of one. While this is going on within the nucleus the cell-protoplasm undergoes active rotary motion, is finally segmentated, and by the time the nucleus is divided is nearly ready for complete division of the cell. While nuclear division is usually bipolar, it may be multipolar: if a rearrangement of the protoplasm is delayed, the result becomes a multinuclear cell, known as a *giant cell.*

The consequence of this endothelial activity is new cell-formation and the construction of a projection from the capillary which soon attains the dignity of its parent vessel, and, as connective-tissue cells form around it, soon becomes a granulation by itself, each granulation, being marked by a capillary loop of its own. Healing by granulation or the granulation process, no matter how set up or caused, is essentially the formation of hundreds or thousands of these tiny structures, a new one being formed on top of those which precede it, while those first formed and deeper down undergo condensation and metamorphosis of tissues, by which they are converted into something higher in the tissue scale. Under ideal conditions true granulation-building proceeds *pari passu* with epithelial reproduction around the margin of the granulating surface, so that by the time granulation-tissue has completely filled the defect, no matter how caused, epithelial covering has been completely constructed and the healing process thus completed. These two processes, however, do not necessarily keep pace with each other; and, should surface-repair take place relatively early, we may have a depressed scar; while, on the other hand, should it not proceed rapidly enough, or, to put it in another way, should the granulating process be too rapid, we have such excess of granulations as shall rise considerably above the surrounding level,

and may, under certain circumstances, become so exuberant that nutritive material cannot be formed rapidly enough, and those granulations farthest away from the centre of supply may die. Such exuberant granulation is often spoken of as *fungoid*, and constitutes that great bugbear in the eyes of the laity which is termed by them *proud flesh*. It has no further significance than that the supply has exceeded the demand and that the granulating process has been overdone. Such exuberant granulations may be cut away with scissors or knife, may be burned away with caustic agents or the actual cautery, or may be disposed of in any other manner without harm and only with benefit; in fact, it is often necessary to suppress this exuberant tendency by caustics and pressure, in order that the desired epithelial covering may be properly formed.

Epithelium, being an epiblastic structure and capable of no other origin save from its like, can only be supplied from those regions where it has pre-existed. Consequently, ulcers involving the external surface of the body demand a lively epithelial reproduction in order that they may have a normal covering. Epithelial activity sometimes becomes retarded, and is much slower toward the termination of the healing process than at the beginning. The epithelial covering of a healing ulcer is always marked by a delicate whitish or pinkish film, which proceeds from the periphery as well as from any little island of original epithelial structure left. It is notorious that after a certain amount of this repair the process sometimes comes to a complete halt, and the various expedients for stimulating and promoting it, as sponge-grafting and the different methods of skin-grafting, have been devised solely to atone for such sluggishness or inability.

Ulcers of small size which are more or less exposed to the air in healthy individuals, while also exposed to possibility of infection, nevertheless seem to escape it, owing to the defensive power of the blood-serum and the active cells. Such discharge as naturally comes from them, when not excessive, undergoes evaporation until a point is reached where a dry *crust* or *scab* is formed. Under this scab granulation proceeds up to a point where the pressure of the scab itself, presumably on the level of the surrounding parts, checks its activity, while at the same time epithelial reproduction goes on until it has been completed. Then the scab, being no longer of use, drops off or is detached by slight friction.

Such is granulation-tissue: at first a mere trellis-work of temporary and delicate cell-structure, traced in a certain amount of intercellular homogeneous substance, into which the budding vessels project, the whole mounting nearer and nearer to the surface, day by day with variable rapidity, diminishing in this regard as the days go by, so that frequently the granulation process comes to an apparent halt before enough new tissue has been formed. While the superficial granulations preserve the characteristics above noted, those deeper down undergo firmer and more complete organization, and the delicate embryonic structures show the same tendency which they do in the growing embryo, by virtue of what Virchow has called *metaplasia*, to become converted into something higher and more dignified in the tissue scale. It is not given to these cells to specialize themselves to the extent permitting complete repair of organs of special sense. Thus, while a wound in the cornea or retina may be completely healed, it heals by cicatricial tissue, and not by repair of the special structures involved. On the other hand, tissues of more common connective type—fibrous, bone, cartilage, etc.—are capable of regeneration; and it seems to be a part of the privilege of these new granulations to merge themselves into that kind of tissue necessary for filling the gap. Nevertheless, the most *common result of granulation is*

its metablastic conversion into fibrous tissue which has the special characteristic of contractility without elasticity. As the result *scars contract;* in consequence of which most disfiguring results are sometimes the almost inevitable consequence of healing of extensive losses of substance. In certain instances it is possible by constant effort to overcome the unpleasant effect of this cicatricial contraction. For example, after extensive burn of the anterior part of the arm, the forearm will be gradually and permanently flexed upon the arm by virtue of contraction of the scar in front of the elbow, unless some forcible means be practised for maintaining extension of the arm for at least a part of the time. So with many other injuries and the various mechanical or other expedients required to prevent the untoward result. Nowhere are the consequences more disfiguring or serious than about the face, where eyelids are drawn out of shape, the contour of the mouth altered, or where sometimes one may see extensive manifestations of this same most undesirable consequence (See Figs. 24 and 25.)

FIG. 24.

Cicatricial deformity following burn (original).

FIG. 25.

Cicatricial deformity following burn: side view of same case (original).

As the result of healing of the granulating surface, we have what is known as a **cicatrix** or **scar**. This is composed of fibrous tissue, probably more or less distorted by virtue of its contractility, and of epithelial covering furnished from the margin of the original ulcer, constituting a thin, glistening membrane, applied closely to the scar-tissue beneath, without intervening fat or tissue which permits of the play of the one upon the other. When this epithelial surface is abraded, it is repaired with difficulty, and a raw

or ulcerating scar is usually a difficult thing to heal. Manifestation of perverted epithelial outgrowth is frequently provoked at these points by the action of continuous irritation. In consequence we have what is generally recognized as the *transformation of a chronic ulcer*, or the site of one, *into an epithelioma*, or possibly, by similar irritation of the connective-tissue elements, into a sarcoma. This is the so-called cancerous degeneration of previous ulcers, and is noted occasionally. The lesion is one which often requires disfiguring, or even mutilating operations in order to get rid of the malignant disease.

FIG. 26.

Epitheliomatous degeneration of chronic ulcer, necessitating amputation (original).

The surface of a superficial scar while thus covered with epithelium shows a complete lack of all the other skin-elements. No hair grows upon such a surface, because the original hair-follicles are destroyed; neither is it moistened by perspiration nor anointed by sebaceous material, because the secretory glands have also disappeared. It is a surface which often needs more or less protection, especially when in exposed situations.

TREATMENT.—Here, as in all other instances, the first effort of the surgeon should be to remove the cause, be it what it may. This may be done by *local*, or may require *constitutional*, measures. If a definite local cause can be made out, its removal may be a slight, or may entail a more or less serious, surgical operation. Aside from this disposal of the exciting agent, treatment must be divided into the general and the local. General treatment is scarcely called for when dealing with healthy ulcers; but in all those instances where the constitutional condition of the patient is below par or where there is a general poisoning or infection underlying the ulcer itself, prompt and energetic constitutional treatment should be at once instituted. In scurvy, for instance, the diet and hygienic surroundings of the patient should be rectified immediately. In syphilis no lasting nor deep impression can be made on local manifestations without general constitutional treatment. In tuberculosis and the other surgical infections much will be accomplished by internal medication, by proper hygiene, as well as by local applications or operation. The importance of these general measures is likely to be under-estimated, and many fail to realize the advantage of combining suitable internal and external therapeutic measures.

Local Treatment.—First of all should be mentioned the complete insistance upon repose which brings about that which we best know as *physiological rest.* The ulcer which may never heal so long as the parts are constantly moved may show a prompt and kindly tendency so to do as soon as the part is put absolutely at rest. This may mean wearing a splint or restraining apparatus, or it may mean confinement in bed,

depending upon the location of the ulcer. Physiological rest will be enforced sometimes by such measures as stretching a sphincter in order to temporarily paralyze it in cases of irritable rectal ulcer, where the principal pain is produced by the reflex spasm of its fibres. Again, the eye with irritable ulcer of the cornea is sometimes kept so tightly closed by the same kind of spasm there that it is necessary at times to divide the lids, or the orbicularis muscle at the angle of the lids, in order to make access to the part. This is in a measure carrying out the principle of physiological rest, because it permits proper exposure and treatment.

Fig. 27.

Cicatricial deformity following specific ulcer (original).

The absolutely healthy and kindly-healing ulcer needs no treatment except protection. Epithelial covering will probably keep pace with filling of the depression by granulations, and all that it is necessary to do is to prevent external irritation. Should there be excess of discharge, the simplest possible absorbent dressing, with enough of some antiseptic material to prevent putrefaction by contamination with the ordinary bacteria of the surrounding air, should be employed. The ulcer which is becoming tardy in its repair may be stimulated by silver nitrate, zinc chloride, or other more or less caustic applications, which act as a spur to the sluggish granulations, destroying those with which it comes in contact, but stimulating those below to do their duty more promptly.

The conventional applications to ulcers fall usually under two categories—the *watery solutions* and the *unguents.*

Among the former which give the most satisfactory results are diluted alcohol; carbolic lotion; solutions of some of the astringents and antiseptics, such as zinc sulphate or chloride, quite weak; potassium chlorate, saturated; potassium permanganate; alum, etc. Of these the potassium chlorate is usually the most satisfactory. Among the various ointments have been suggested nearly all possible combinations imaginable of the soluble and insoluble antiseptic drugs, in connection with various excipients like vaseline, lard, lanolin, etc. Among those substances most commonly used are perhaps zinc oxide, bismuth subnitrate, boric acid, salicylic acid, iodoform, aristol, etc. The latter preparations have the advantage that surface evaporation does not lead to drying and formation of crusts whose detachment gives pain. Aqueous solutions permit of more easy and comfortable washing of the parts without need for friction to remove ointment. Each class of preparations, therefore, has its advantages, and circumstances would best decide which would be the better for a given case. Balsamic preparations have also been largely used in time past, among them especially balsam of Peru. This, mixed with 10 per cent. of guaiacol and 5 per cent. of iodoform, makes a combination which I am very fond of applying to tubercular and all specific forms of ulcer.

Of late the investigations of the laboratory have led to the employment of numerous peptonized preparations, among which may be mentioned peptonized cod-liver oil and some of the partially or predigested foods, such as *bovinine*, etc. These appear to have the power of digesting sloughs and of causing a speedy separation or disposal of everything which one wants to get rid of in the endeavor to secure a healthy con-

dition of the ulcerating surface, and give in many instances most satisfactory results. Glycerin solutions have also been used (especially boroglyceride), which act by abstracting water, and which are particularly useful in certain conditions where the granulations are quite œdematous. When sloughs are present it is frequently an advantage to dust over them some of the preparations, like papoid, pepsin, etc., which have the power of catalytic disposition of decomposing material without reference to action of bacteria. Under their use there seems to be a sort of solution and disposition of these dead products. When one has to do with a torpid or callous ulcer whose surface is covered with a thick, immovable film, where the tissues apparently are not dead, yet not alive, the addition of some digestive agent, coupled with the favoring action of heat and moisture, such as are to be secured by the application of a poultice, will, if properly enforced, lead to the speedy separation of a slough. While an ulcer should never be continuously poulticed, nor a healthy ulcer under any circumstances, poultices are yet a valuable means of first treating a limited class of cases. With a foul ulcer—one from which the discharge is more or less offensive, due usually to decomposition of sloughing masses not yet separated the method of *continuous immersion in hot water*—when it can be carried out, is always preferable to all others.

Various expedients may be practised to effect this purpose, from a domestic pan or pail up to the porcelain bath in which the patient's whole body is kept continuously immersed. The water should be as hot as can be comfortably borne, and may be impregnated with a very small percentage of some antiseptic, like mercuric chloride, zinc chloride, or something of that kind. This is, for instance, an admirable method of treating those ulcers caused by extensive burn, from which much tissue has always to separate by sloughing, and on whose surface there are always patches which hover between tissue-life and death for some hours or days, which possibly may be redeemed under the favoring influence of hot water. For the treatment of phagedenic ulceration also, hot water offers perhaps the best method, although there is no reason for not combining this with previous treatment with bromine, caustics, or other measures.

Another method of stimulating is by resort to compression, either by rubber bandages, straps, or other means. The old method of strapping used to be much favored. Of late all of these methods have rather fallen into disuse, because of the preference of modern surgeons for the speedy conversion of a chronic ulcer into a fresh sore and its treatment by skin-grafting or other methods. A method more in vogue than strapping, and in some respects easier of performance, is that by use of the elastic rubber bandage. The treatment by compression is based upon supporting the surrounding parts, equalizing the pressure, and overcoming the collateral œdema which is one reason for sluggishness of repair.

Many ulcers are surrounded with such firm, indurated borders that it seems impossible that any active regenerative process can arise from such source. Hence incisions have been practised for centuries. These have been made radially from the centre or have been made parallel to the margin of the ulcer, or sometimes the firm, dense tissues have been minced or chopped by a series of cross-cut stabs or incisions ; as the result of which renewed activity has been set up, and an impetus, oftentimes sufficient, has been given to the healing process. These methods, however, have now yielded to that just above alluded to. The comparatively recent ulcer in which granulation has come to a stand-still is often treated with the *sharp spoon* or *curette.* The result of this has been to provoke again a speedy renewal of granulation efforts, and treatment by

curetting is standard and often useful. Actual cauterization of the ulcer with a view to such complete destruction of its covering and border as shall lead to their separation by the sloughing process is occasionally practised. This is perhaps best performed with the actual cautery. It lacks, however, the valuable features of the operative method to be described below. Modern methods have made it plain that it is often an absolute waste of valuable time to resort to the older expedients of stimulation, incising the edges, etc., and that one can accomplish by an operation in perhaps three weeks what ten times that length of time would fail to do by older methods. The *most effective method*, therefore, in dealing *with old and chronic ulcers* is to anæsthetize the patient, to *excise the entire affected area*—*i. e.* the surface which ought to be granulating and the firm border and tissue in its neighborhood—and then to cover this surface either with *skin-grafts*, pared off with a razor according to the Thiersch method, or with a strip of skin whose full thickness is raised, which is taken from surrounding parts by some auto- or heteroplastic method. This line of treatment is so far preferable to all others that, except in case of refusal of the patient to submit to it, it is the one which must hereafter universally commend itself. It may afford opportunity for extensive plastic operations or for the exercise of the best discretion and knowledge of experienced men; yet cases are rare in which it cannot be successfully carried out. These methods of skin-grafting have so far supplanted the older method of sponge-grafting that the latter is now scarcely ever practised. It may possibly have a sphere of usefulness in certain ulcerated cavities, but under all other circumstances it must take a position far below the plastic methods in practical value.

Finally, ulcers of specific type—syphilitic, tubercular, leprous, glanderous, etc.—all need methods in which the first effort shall be not so much to arrange for healing as to dispose of infectious material. The knife, the scissors, the sharp spoon, come first into play here, the surgeon bearing in mind that almost all this material is more or less infectious, and that inoculation of his own hands is possible as the result of carelessness. After taking away with instruments all the granulation-tissue with its surroundings which seems to expose to danger, it would be well to thoroughly cauterize the part with the actual cautery, nitric acid, bromine, zinc chloride, or something of the kind as a matter of insurance of the desired purpose.

As the result of the caustic there will be superficial separation of the cauterized tissue, beneath which, however, should spring up healthy granulations. Such an ulcerated surface, having by this means been converted into what we may call a healthy ulcer, becomes then amenable to the treatment already mentioned. The ulcer covered with fungous or exuberant granulations—*i. e.* the *proud flesh* of the laity—should be rapidly scraped or burned down at least to the level of the surrounding parts, the quickest method being that by which the knife or scissors is used, compression for a few moments always sufficing to check hemorrhage. Common attention after this will be all that such a surface needs.

The markedly *hemorrhagic ulcer*, whose surface bleeds on the slightest contact or disturbance, is often a cancerous ulcer, though not necessarily so. This ready bleeding is usually the cause of the extreme fragility of the tender walls of the rapidly new-formed blood-vessels. In many instances it is enough to thoroughly scrape until one comes

down upon harder or more resisting tissue. Hemorrhage may be profuse for the moment, but it is almost invariably easily controlled. Caustics may then be applied or not, according to the judgment of the surgeon.

Another method is to treat such a surface with the actual cautery. Another is to operate, even in the presence of really incurable disease, simply in order to check tendency to fatal hemorrhage before the natural tendency of the disease has expended itself. In a general way, with regard to all small ulcerating cancerous surfaces, one may say that if they bleed excessively or are unduly irritable, it is perfectly legitimate to attack them by operative measures in spite of the impossibility of effecting a cure.

Numerous other methods of treating ulcers may be found in the older text-books, but they have, in whole or in part, been abandoned for the comparatively few already mentioned.

CHAPTER V.

GANGRENE.

By Roswell Park, M. D.

This is known also as necrosis, although by general consent this term is usually limited to gangrene of bone. It is known also to the laity as *mortification*, and to the older writers, especially when soft parts die and separate in sloughs, as *sphacelus*. *Gangrene means death of tissue in visible and more or less circumscribed masses.* It is to be distinguished from ulceration because now we have to deal not with a process of molecular disintegration, particle by particle, but with death *in toto and synchronously* of a large perhaps innumerable number of cells. Gangrene is described as due to causes which may be—

A. *Traumatic*, including the so-called thermal causes as essentially mechanical injuries. Under this head would come all cases where *injury* is the primary cause, whether this injury be the crushing of a limb, the separation or occlusion of its main blood-vessels, the division of its main nerves, the crushing or pulpefying of its entire structure by machinery or accident, and also those so-called *thermal* cases which are due to intense heat or intense cold. To these might be added the *chemical* causes, comprising injuries by powerful caustics, alkalies, or acids, which are known to cause speedy death of every living tissue with which they come in contact.

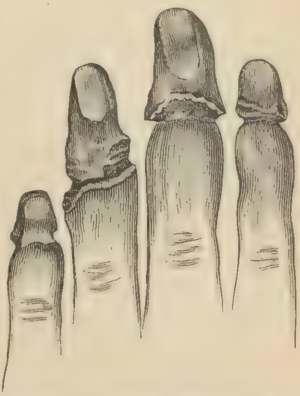
B. *Local Causes.*—These are largely connected with *ischæmia*, produced in one way or another. *Gangrene from œdema*—itself the result of passive hyperæmia and exudation—is not infrequent, the most common expression of this condition being seen, perhaps, in the external genitals of the male. *Embolism* due to valvular heart disease, *thrombosis* due usually to a preceding phlebitis, but possibly to marasmic origin, especially met with after confinement, with disturbance in the uterine sinuses, shutting off the circulation by endarteritis, which thus assumes the form *obliterans*, are some of the local causes which concern the blood-vessels alone. In fact, the majority of cases of spontaneous gangrene are probably due to changes in the vessels, endarteritis being the cause of a condition known as atheroma of vessels, in which fungoid outgrowths or, rather, ingrowths into the vessel-lumen, are common. Any one of these, if detached, may serve as an embolus. The degenerative excavations in the thickened walls of the blood-vessels which discharge more or less cholesterin and other débris, and which have in time past been known as *atheromatous abscesses* (misnomer), are frequently the

precursors of the disease under consideration. As the result of these changes alone, without reference to formation of emboli, vessels may become completely occluded, especially when slightly injured.

Extravasation of blood is another cause connected with the blood-vessels, this coming usually from traumatic rupture, possibly from idiopathic causes. At any rate, the tension in the part may threaten its life because of the pressure which overcomes the circulation of blood. *Ligation* of the main trunk of an artery is sometimes followed by gangrene, no matter how carefully done, collateral circulation being insufficient to sustain the nourishment of the part. In certain fractures, simple as well as compound, the blood-supply of a part is rudely broken off by injury to a blood-vessel in such a way as to cause local or general death, either of a bone or of the entire limb. Flaps made for plastic purposes, arranged without sufficient regard to their proper blood-supply, or so dressed after operation as to sustain undue pressure, are often so shut off from the heart as to die for want of blood. Finally, gangrene may be the result of *pressure* either from splints, bandages, etc., or from *tumors* increasing in size, or possibly, as in certain pressure-sores, etc., from the mere weight of the body. Here, too, *chemical agents* must be mentioned, referring now to the peculiar action of certain *foods or drugs*, particularly ergot. Thus, antiseptic solutions, particularly carbolic acid, may be made strong enough to destroy the vitality of certain tissues. Carbolic gangrene (Warren) is a possibility not to be forgotten.

C. *Constitutional Causes.*—Among these are to be mentioned particularly that symptom-complex ordinarily known as *diabetes or glycosuria*. It is notorious that this means a depraved condition of the system in which gangrene is threatened or permitted under circumstances which otherwise would have little or no disastrous effect. Thus *diabetic gangrene* has come to be one of the recognized manifestations of the general subject. That the trophic nerves have a more or less pronounced effect in determining gangrene in certain cases seems to be now quite well established. It is well known how quickly *bed-sores* form after injuries to the spine, while in certain nervous affections a minimum of friction of the skin may determine its death, particularly about the labia or scrotum. It is said that the insane, when made to sleep by chloral, may develop decubitus from pressure in a single night.

Fig. 28.



Raynaud's disease; symmetrical gangrene; digiti mortui (Lanceraux).

There is also a well-known form of *symmetrical gangrene*, known sometimes as *Raynaud's disease*, which is characterized by symmetry of lesions and absence of definite pathological changes. The so-called *digiti mortui*, or *dead fingers*, are expressions of trouble of this same character; so is also that condition described by neurologists as *erythromelalgia*. A condition almost leading up to gangrene, but perhaps not absolutely terminating in such a way, has been known as *local asphyxia*,

which seems to be a condition of arterial spasm with venous congestion and slight œdema.

As constitutional causes also must be included the deleterious effects of certain drugs, particularly ergot and phosphorus. A hundred years ago and more *ergotism*, or gangrene produced by eating diseased rye, made great devastation among the peasants of Central Europe, whole hands and limbs being involved in the gangrenous process. This is a condition now perhaps never noted, at least in this country. The selective affinity of *phosphorus* for the osseous structure of the lower jaw is also well known, and gangrene of the bone—*i. e.* necrosis—used to be a frequent lesion among the workers in match-factories where phosphorus was used. This condition has been almost abolished by wise legal enactments. *Mercury*, too, when given to excess or for an injudicious length of time, produces a gangrenous condition of the gums and alveolar process, by which the teeth are loosened; along with which gangrenous ulcers appear also about the mouth and sometimes elsewhere.

D. *Infectious Causes of Gangrene.*—In the instances already mentioned I have avoided reference to the infectious micro-organisms. There remain to be considered special types of gangrene due to the activity of certain micro-organisms—among these that variety of gangrene known to our fathers as *hospital gangrene*, as well as *phlegmonous erysipelas*, *malignant œdema*, *gangrenous emphysema*, *noma*, *ainhum*, etc.

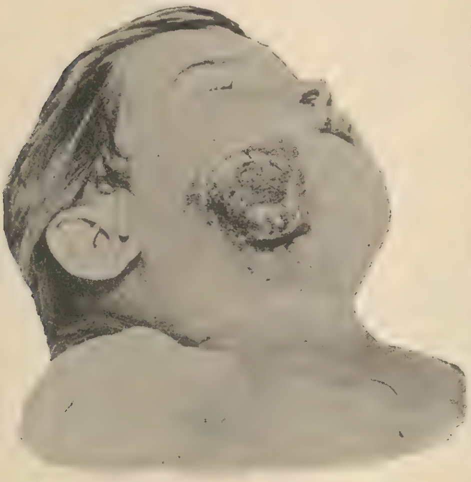
Gangrene as the result of infectious processes is met with, for instance, in severe cases of phlegmonous erysipelas, where death of tissue seems to be due to the combined influence of the invading organisms and of mechanical agencies—*i. e.* tension produced by stasis and exudation, with such stretching of tissues or overcrowding them with inflammatory products as to virtually strangle them, in consequence of all of which they die. Gangrene of an entire hand may thus result, or, more commonly, the gangrene is limited in extent to the more superficial parts, so that sloughs separate. A peculiar and specific form of gangrenous inflammation is that also known as *malignant œdema*, which is due to a peculiar anaërobic bacillus, and which will be treated of separately under a distinct heading. Quite like it in several respects is the gangrenous emphysema of certain writers, known also as the fulminating form, or, as the French call it, the "*gangrène foudroyante.*" More or less emphysematous condition may accompany malignant œdema; yet that we do get gaseous forms of gangrene without the specific bacillus of malignant œdema is established.

Hospital gangrene, so called, has been in years past the terror of military surgeons and camp hospitals. As a type it has almost completely disappeared from observation, and, in its old manifestations at least, is now practically never seen. During the days when it was most common there was no application of knowledge of bacteriology, and we are to-day practically in the dark as to whether it was due to a specific organism, or was not, on the other hand, due to causes already described acting upon constitutions vitiated by exposure and upon tissues made vulnerable by fatigue and injury. The latter is the more probable. Clinically, it assumed the aspect of gangrene which spread with terrific rapidity, so that within a few hours the death of an entire limb might be determined, almost without power to check it. After terrible experience with it in numerous camps, military surgeons found that the most effective agent with which to combat its destructive power was bromine, which was applied dilute or in full strength, as appeared best.

Noma, known also as *gangrenous stomatitis*, *cancrum oris*, and *gan-*

grœna oris, is a term applied to a form of tissue-necrosis affecting the cheeks or parts about the face of young children, occurring frequently as a complication of the exanthemata. A similar condition occasionally involves the external genitals. From the fact that it seldom passes across the middle line, it has been regarded by some as of neurotic origin. Naturally, bacteria are always found in the decomposing tissues, but whether there as cause or as result is not yet absolutely established. The probability is, however, that we have to deal with a specific form of infection. The loss of substance is usually so great as to determine complete perforation of the cheek, so that the jawbones may be laid bare. The gums and alveolar processes also frequently share in the process, and the teeth accordingly drop out. Death of tissue is rapid, and septic infection may accompany it to such extent as to cause death of the little patient within two or three days. While theoretically most vigorous measures are necessary for combating it, these patients are often so reduced as to preclude the possibility of doing much, and death is the common termination of noma. Should patients recover, there is extensive deformity as the result of cicatricial contraction.

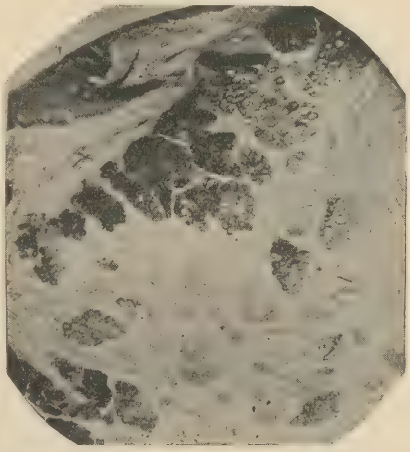
FIG. 29.



Noma (Neisser).

Along the coast of Africa and in the West Indies there occurs among the negroes a peculiar gangrenous affection of the toes known as *ainhum*. This may assume either the moist or the dry type of gangrene, but the result is gradual separation of the part, usually by the dry process, as if it had been strangulated by a ligature. The disease is very slow and may extend over ten years. The minute cause is as yet unknown.

FIG. 30.



Section of noma cheek; showing tissue of necrosis from bacterial infection (Miller).

Finally, gangrene is the termination of the infectious process in several other zymotic diseases, among the best illustrations being that afforded by *diphtheria*. The formation of diphtheritic ulcers in the mouth and the vulva, about the eyes and elsewhere, as the result of separation of sloughs, is too frequent to pass unnoticed, yet at the same time does not essentially differ from the sepa-

ration of sloughs due to any other specific cause. All these acute zymotic diseases, therefore, need to be regarded as among the possible causes of gangrene by infection of tissues.

The *symmetrical gangrene*, often paroxysmal, affecting the fingers and toes, described by Raynaud and often called by his name, is due to vasomotor spasm, and is accompanied by neuralgia and sensory disturbances, with coldness of the part and discoloration suggestive of impending gangrene. (*Vide* above.)

Billroth and others have also described a *spontaneous* or *angio-neurotic gangrene* of the extremities, occurring during youth, in abrupt distinction to senile gangrene, whose course is tedious and painful, and which will usually necessitate amputation. The cause of this condition has been found to be a well-marked arterio-sclerosis and thrombosis, both in the arteries and veins. This form of gangrene occurs most often in the frigid zone—*e. g.* in Northern Russia.

Fig. 31.

Moist gangrene of foot (original).

Gross Appearances.—In a general way, tissue-death, known as **gangrene**, assumes two quite opposite types—**the moist and the dry.** In *moist gangrene*, aside from those general appearances which plainly indicate commencing putrefaction of tissues, and the loss of heat due to shutting off of the blood-supply, one of the most characteristic features is the formation of a so-called *line of demarcation*—*i. e.* border which separates the dead from the living tissues. While this is usually plainly indicated by a red line which more or less abruptly separates the discolored, usually dark, dead portion from the bright-red, congested appearance of the living tissues, we note that this area of redness shades out into a more and more natural appearance as we pass upward, while below the line we note a surface, usually covered with blisters, from which exudes a foul-smelling altered serum, while the gangrenous portion usually assumes a dark, finally an almost black, appearance, retaining only the crude outlines of its original shape. Along with this the objective evidences of putrefaction are unmistakable, appearances and odor being characteristic. With all there is more or less constitutional disturbance, and a recognizable, often a profound, condition of septic infection, due to the fact that along the line of demarcation absorbents are still active, and that the poisonous products of putrefaction are being absorbed into the general system. Consequently, *collapse*, *profuse perspiration*, *septic diarrhœa*, etc. are commonly noted. In gangrene from frost-bite the process is usually somewhat more slow

than in the more distinctly traumatic forms. In *gangrene from extravasation of urine* the separation of sloughs is often extensive, and complete sloughing of the scrotum with exposure of the testicles is a not infrequent result. In *decubitus* or *bed-sore* the process is still more slow, but always of the moist type. After a variable length of time there is separation of slough and a resulting large, often foul, ulcer.

Dry—or, as it is usually known, *senile—gangrene* presents a very distinct contrast to the moist type. It is met with almost invariably in patients over fifty, and occurs often as the result of causes which are slow of action. As the result of the shrinking and corrugation of the tissues, along with the dryness of the same by evaporation, we have a peculiar appearance known as *mummification*, the foot, for instance—for the feet are usually first involved—very much resembling the foot of a person who has been embalmed, except that it is discolored. It is possible sometimes to have a combination of moist and senile gangrene, especially when there has been infection by which putrefaction is permitted. When from the outset putrefactive processes are absolutely prevented, the gangrene of this type is almost invariably dry. In practically all of the cases of this character there will be found evidences of vascular disease, usually in the femoral artery and its branches. Gangrene of the foot alone is most commonly due to endarteritis, while gangrene of the foot and leg together are usually due to embolism or thrombosis.

Signs and Symptoms.—Aside from those already mentioned, which are recognizable at a glance, there is but little more to say. The appearance and the odor of a part will quickly indicate impending or actual traumatic gangrene. The pallor, the coldness, and the dryness of senile gangrene are also characteristic. In the latter form, at least up to a certain point, constitutional symptoms are not indicative nor essentially of septic type. Just so soon, however, as a process of spontaneous separation begins putrefaction is inevitable and sepsis unavoidable. In moist gangrene there is seldom acute pain. This is one of the predominating subjective features of the senile forms, at least in many instances. Hemorrhages occur, sometimes terminating fatally, in the moist forms when large vessels are eroded. This is particularly true of the *phagedenic* or *hospital* form. A recognition of their possibility may enable us to avoid sudden death from this source.

Treatment.—We shall speak first of treatment of *threatening gangrene*, which, so far as it may be possible, should impel us to attack and remove the cause. Threatening bed-sores may be avoided by equalizing surface pressure, and this best with the water-bed; by protecting the skin or by stimulating and toughening it with alcoholic and astringent lotions; by frequent changes of position; by attention to the heart, which should be stimulated to a point that may make it capable of forcing or distributing blood equably over the entire body. So, too, with limbs which are enveloped in dressings or splints: it is always well to leave exposed the tips of the toes or fingers, at least when practicable, in order that discoloration of the same may be quickly recognized and the threatening disasters averted. Local gangrene as the result of pressure by tumors, aneurisms, etc. cannot always be averted, though one realize its imminence. These are cases where one needs

must sit hopelessly and helplessly by and see that occur which he cannot obviate.

For gangrene which has actually occurred there is but one relief, and that is the *removal of the dead and dying tissue.* The method and location of the operation must be determined somewhat, however, by the general character of the cause. For a case of acute traumatic gangrene amputation at the nearest point of election above the injury will often suffice. In case of gangrene from frost-bite the tissues in the neighborhood of the line of demarcation are often so affected or their vitality so compromised that to simply separate the tissues along the lines at which nature is endeavoring to remove them is not enough, and to go an inch or so above this line is simply to operate in tissues which bleed readily and heal badly. Consequently, here it is often good judgment to select a suitable point at some distance above. But it is especially in the forms of diabetic and senile gangrene that surgeons have now laid down the rule that if *amputation* be done at all, it must be *high*. If one have senile gangrene of the toe, for instance, as the result of disease of the vessels, he may be sure that it will be wise to amputate at least above the ankle; whereas if any greater portion of the foot be threatened, it will be eminently judicious to amputate above the knee, if at all. I have repeatedly under these circumstances found the tibial arteries so brittle as to snap under a ligature, and even the femorals so disorganized as to require handling and ligating with the greatest caution. These high amputations are therefore necessitated by the condition of the vessel-walls; all of which must needs be explained to many patients before they can appreciate the reasons for such high operations or consent to them. While amputation for traumatic and acute cases is, in the majority of instances, if not too long delayed, successful in saving life, in the senile, and particularly in the diabetic forms, it is in the majority of cases a disappointment; and my advice to all, especially to young men who are chary about assuming responsibility, is to have these matters definitely understood and the situation thoroughly canvassed before consenting even to make such an operation, urgently as it may seem indicated.

PART II.

SURGICAL DISEASES.

CHAPTER VI.

ON AUTO-INFECTION, ESPECIALLY IN SURGICAL PATIENTS.

By Roswell Park, M.D.

One of the greatest advances made in recent pathology has been the establishment of the fact that a great many of the morbid conditions from which the human race suffer are those due to causes arising entirely from within their own systems and in consequence of deficiencies of elimination or of perverted physiological processes which, in large degree, are themselves the result of errors and indiscretions in diet, in manner of life, in habits, etc. That these general facts have been recognized for centuries is perhaps a credit to the powers of observation of practitioners of past generations. Exact knowledge, however, has come only with exact laboratory methods of research and most painstaking study of the secretions and excretions, both under normal and morbid conditions. The subject of *auto-intoxication* has been too commonly relegated to the domain of internal medicine, and has been supposed to be one in which the surgeon, as such, need take only passing interest.

This is a most sad and egregious error, however, and that surgeon will prove himself the best master of the situation who is thoroughly conversant with all that the general topic of auto-infection comprises and implies, for he will find that his surgical patients do well or badly just in proportion as he maintains equilibrium between ingestion and egestion, or as he realizes that retained excrementitious products are among the most active predisposing causes of what may a little later appear as distinct surgical sepsis. For this purpose, therefore, the present chapter is included in a distinctly surgical text-book. It includes not only the interesting topics of the ptomaïnes and leucomaïnes, but comprises much more, as shall be seen.

It pertains in large degree to the intimate secrets of the chance meeting of man and microbes, which are so constant, yet so often without result. In the consideration of auto-intoxication is to be found much of the explanation why infection, which apparently occurs so easily, is yet relatively so uncommon. It brings up the statement so emphasized by Bouchard, that physicians ought not to permit themselves to be occupied alone with the research after microbes, but that they ought to busy themselves as well with investigating the circumstances which disarm the organism against microbic invasion.

The *alkaloids* are by no means the only poisonous products which the human body may produce and retain. The most important excrementitious material of all—*i. e. carbonic dioxide*—could not be retained

in the organism for more than a few moments without death as the inevitable consequence. The various *soluble ferments* elaborated by certain glands may exert deleterious influence, both local and general; and in the saliva are also found products which are not ferments. The *biliary acids* also, if they do not find free escape, may produce fatal poisoning. So also *leucin*, *tyrosin*, and all of the excrementitious products which arise from insufficient liver-activity, are capable of producing forms of intoxication—such, for example, as *eclampsia*, etc. By no means all of the alkaloids produced within the body are poisonous. Some of them are met with in the normal tissues, and they are, perhaps, only one of the many results of the disassimilation of animal cells. Nor are all these poisions of bacterial origin, although many are only formed in the presence of microbes.

Throughout his life man is inhabited for nearly the whole length of his digestive tube by inferior and parasitic vegetable organisms. When some of their products are absorbed more or less poisoning is sure to ensue, while, again, abnormal conditions not primarily due to them may, nevertheless, prevent their elimination, and intoxication thus ensue.

From these constantly-menacing sources of intoxication man escapes by virtue of his intestinal, cutaneous, pulmonary, and renal emunctories. For instance, the usefulness of the perspiration is shown by the odor which it assumes under the influence of certain disorders. Amongst hypochondriacs and the inactive, fatty acids are eliminated abundantly by the skin. Hence the odors of hospital wards, asylums, prisons, etc. So, too, in the case of many who suffer from deep-seated, indolent ulcers, the odor of the skin is suggestive of the presence of pus. During twenty-four hours there are eliminated from the lungs 1100 grams of carbonic dioxide, water, etc., which sometimes contain ammonia and various volatile fatty acids; all of which will explain fœtor of breath when it is the result of incomplete nutrition and destruction of food. Of all the *organs of elimination*, the most important is the *kidney*, which can never be charged with reabsorbing a part of its own products, as does the intestine. The kidneys eliminate fluids and solids, not gases. The most important of the toxic principles contained in the urine are—

1. *Urea*, which ordinarily plays a most important and useful rôle in the economy, since it possesses the property of forcing the renal barrier and removing along with itself both the water in which it is dissolved and other toxic matters. Urea is toxic, but only in the sense that any other substance, even water, may be so—*i. e.* it is toxic only in relatively enormous doses, much less so than sugar, and no more so than the most inoffensive salts. This is contrary to generally received views, but is experimentally clearly established by the researches of Bouchard.

2. A *narcotic* substance, and

3. A *sialogogue* substance, whose composition is unknown.

4, 5. Two substances having the property of causing *convulsions*, one having the power of *contracting the pupils*. Composition of both unknown.

6. A substance which *produces heat* by diminishing heat-production —possibly a coloring matter.

7. *Potassium salts*, which are really convulsing agencies, and are the most toxic perhaps of any of the poisons contained in the urine. The

chloride of potassium, for instance, is toxic at 18 grams for every kilo of animal.

Salivation and *myosis*, as well as diarrhoea, are often noticed in so-called *uræmia*. In that form known as hepatic uræmia, when the liver no longer forms urea, the kidneys scarcely act. In other words, if urea be no longer present in the body, the kidneys are deprived of their principal stimulation to physiological activity. Consequently, urea, for so long a time the bugbear of physicians, is shown to be most dangerous when absent. When urea is deficient it is most wise to resort to withdrawal of large quantities of blood-serum or of water in which the other toxic substances are dissolved. This is best done by *venesection*, whose value in so-called uræmia past experience amply corroborates. When kidney activity ceases intoxication is most likely to be produced by potassium salts.

Correct performance of *hepatic function* is also most necessary in order that surgical cases may progress without disturbance. Bile escapes direct absorption by the blood, but not all contact with it, since in the intestine it is in contact with mesenteric capillaries, but must pass again through the liver, which shall take it up anew and pour it once more into the intestine.

Bile in the blood is always dangerous, although its toxicity is relatively much smaller than has been generally supposed. Of all the bile thrown out into the duodenum, we are only able to account for about one-half. Its coloring matter and biliary salts are metamorphosed. Yet in certain morbid conditions bile, as such, may be reabsorbed in the liver along the margin of the hepatic cells. In these cases, if the kidneys remain permeable, auto-intoxication is simply threatened; if they have ceased to be permeable, actual auto-intoxication is the result.

Putrefaction of intestinal contents affords another source of auto-intoxication. This comes both from imperfect metamorphosis of food and from bacterial infection. Here the conditions are most favorable. Nitrogenous substances become peptonized, and peptones form the best culture-media for microbes. Water is present in sufficient quantities, and a constant temperature of 37° C. is maintained. The digestive tube is always open, and invaded at frequent intervals. By such mechanism are formed those products whose effects are revealed in the so-called *putrid fever of Gaspard*. Brieger has shown that alkaloids are developed during the act of peptonization. Fecal matter contains also *excretin*, whose toxicity has been amply proven, and several other alkaloidal substances, soluble in various media, varying in toxicity. The potassium and ammonium salts contribute largely to the toxicity of fæces; bile also, but in lesser degree. It has been shown that the aqueous extract of putrid matter is very toxic, but that of fecal matter is much more so.

From the tissues, the secreting organs, the ingesta, and the various putrefactions going on within the body come the principal toxic products introduced into the blood, and which it is possible to estimate. The elimination of these is thrown almost entirely upon the kidneys; but it does not follow, because the urine is strongly toxic, that the blood is habitually so. If the urine were not toxic, the blood would rapidly become so. Auto-intoxication practically does not happen to those whose kidneys work perfectly naturally.

A normal kidney secretes ordinarily from 1200 to 1500 c.c. of urine, but it may secrete as much as 25 litres. Instead of 20 to 25 grams, the average elimination of urea, it may eliminate 120 grams, as in cases of diabetes insipidus. Instead of the ½ gram of uric acid which is ordinarily eliminated in twenty-four hours, it may in cirrhosis and leukæmia eliminate 8 grams or even more. Even 140 grams of sugar per litre may be passed off in this way; and so fat, peptones, albumen, and other substances, which it ought not to permit to pass, may escape through its channels. The few grams of albumin which the patient with Bright's disease

eliminates each day are made too much of. Such a slight spoliation is not capable of causing deterioration by itself, for a nursing woman loses ten times as much by her milk, and her system is not thereby weakened. It is only when albuminuria is accompanied by fever or by impaired nutrition, or when it is intense—in other words, it is only when albuminoid loss is serious, as in cases of abundant leucorrhœa, dysentery, suppuration, and ascites—that it becomes really serious.

The most serious features of the various conditions grouped in time past under the heading *Bright's disease* are their *so-called uræmic* features. These happen at the period when retention of toxic products is peculiarly harmful. So long as the urine be ample in amount and of high enough density—*i. e.* containing enough toxic materials in solution—there is no danger of intoxication. But when it no longer eliminates in twenty-four hours what it ought to, then we see the chronic and paroxysmal nervous accidents, the œdemas, fluctuations of temperature, etc., which are properly considered so serious. Oliguria with urine of increasing density and general œdema of the tissues may be noticed, although the other secretions continue natural and the tongue be moist. So long as the normal amount of solids is eliminated, this form of "uræmia" may be due to mere accumulation of water, and may not be serious. *Ordinarily, uræmic patients are those whose urine has lost its toxicity.* Usually on the day in which so-called uræmic accidents happen the urine quite ceases to be toxic and is scarcely more so than distilled water. Urea alone is not to be held guilty for this condition. In order to kill a man with urea it would require the quantity which he makes in sixteen days. Nevertheless, it may become harmful after undergoing transformation into ammonium carbonate or other substances.

Among the most poisonous substances in the urine are the *extractive* and *coloring materials.* Normal urine loses one-half of its toxicity by decoloration; bile acts in the same way. *Urea* alone represents about one-eighth of the total toxicity of urine. *Ammonia* is toxic, but present in small amounts. The *coloring matters of the urine cause two-thirds of its toxicity*, the remainder of which is to be ascribed to its mineral salts, which it contains in the following proportion: A litre of urine ordinarily contains 44 grams of solid matter, of which 32 are organic, 12 mineral. Of the latter, potassium salts constitute 3 grams, sodium salts 7.50, and other earthy salts constitute the remainder.

In these conditions physicians have, in time past, relied largely upon purgatives, hoping thereby to remove urea from the blood. But intestinal elimination has no elective affinity for it, and removes it only in its normal proportion with the balance of the blood. Purgatives, however, help, first, by dehydrating the tissues—*i. e.* removing water with toxic material in solution. But they should be followed by restoring to the tissues pure water. By bleeding more extractives are removed than by any other channel, except by the kidneys. A bleeding of 32 grams removes from the body as much toxic matter as would 280 grams of a liquid diarrhœa or 100 litres of perspiration. This much may be removed by two leeches. It is especially in the *subacute nephritis of scarlatina, etc. that bleeding finds its greatest indication.* If the kidneys be chronically diseased, the utility of bleeding is doubtful, for we cannot continue it incessantly. Between the arterial capillaries of the bowels, however, and the liver is found a mass of blood accumulated in the *portal* vessels. This may now be regarded as a reserve which can be thrown into the general circulation when needed, in order that thereby we may augment arterial tension and so increase kidney function. *Cold injections* into the bowels will often accomplish this, and serious *anuria often disappears after their use.* It is reasonable now, also, to make deliberate use of urea by subcutaneous administration as the most powerful diuretic known, surface friction, caffeine, digitalis, etc. being far behind it in

efficiency. In that particular form of intoxication noted in the eclampsia of puerperal patients *inhalations of chloroform* are most valuable. Potassium salts should, under these circumstances, *never* be employed. We may also take advantage of the fact that an exposure of urine in compressed air will diminish its toxicity, on account of contact with the oxygen, as well as of the fact that the most toxic bacteria are those which grow without oxgyen. Consequently, by causing these patients to inhale this gas we may in large measure overcome this kind of auto-intoxication.

The value of a thoroughly active liver is also not appreciated to the full extent by most surgeons. The blood of the *portal vein* is so much more toxic than that of the *hepatic vein* that it is most evident that the function of the liver is, in large measure, to purify and remove from the blood that comes from the intestines no small amount of highly toxic material. This has been called by Flint and others the *depurative action* of the liver. In order that it may functionate properly it is well to limit the food to the minimum of putrescible substances; for which purpose a milk diet, when well tolerated, comes the nearest to the ideal. The intestinal canal should also be cleared of putrefactive material so far as possible, and, in addition to *purgatives*, drugs like powdered charcoal, bismuth salicylate, iodoform, naphthaline, salol, etc. should be administered. Many uræmic accidents supervening after surgical operations may be atoned for, and the condition made to pass away, by internal administration of naphthaline and charcoal.

Man forms by his liver in eight hours enough poison to kill himself. Of these liver-poisons the *urine does not eliminate half.* In fact, it would take the urine of two days and four hours to get rid of the quantity of poison of hepatic origin necessary to kill. Bile is nine times as poisonous per volume as is urine. Its principal toxicity comes from its coloring material—of which the bilirubin is the most powerful—and its salts, all of which, when precipitated, escape reabsorption.

That facts above stated or others related thereto have not been entirely lost sight of by surgeons in time past is shown by such expressions as *septic enteritis*, *enterosepsis*, etc. which are used by various writers. In previous writings I have made a separate and distinct topic of so-called *intestinal toxæmia*, which here I have preferred to introduce as simply one of the many possible auto-intoxications. To be sure, it is a condition not always permitting of exact definition, nor, still less, can the exact toxic agency be certainly indicated in a given case. Nevertheless, it has been made plainer and plainer within the past few years that there is perhaps no condition which so *predisposes* to *sapræmia*, *septicæmia*, or even *pyæmia*, as this vague condition of intestinal toxæmia, which, nevertheless, is so often present. I have long maintained that many surgical patients present forms of blood-poisoning in which the poison has *not* proceeded from the wound, and for which the surgeon is not responsible, except in so far as he may have neglected to avail himself of certain precautions based on facts which this chapter purports to teach.

The practice of preparing patients for operation by a course of purgatives, emetics, etc., which has prevailed at many times in the past, is based upon the crude recognition of certain principles which it is desired here to make much clearer. Some one, if not each, of the general symptoms included under the name *enterosepsis*, *stercoræmia*, *copræmia*, or whatever one may choose to call it, is certainly due to the activity of the colon bacillus, which seems to be made more viru-

lent by certain conditions of diet or retained fecal excretions, and to such an extent that it now wanders widely from its normal habitat and may be found in distant parts of the body. *Enterosepsis may be mistaken for surgical fever*, and is to be distinguished from it, perhaps, only by the careful study of the excretions of a given case and establishing the fact that they are free, and that consequently pyrexia, etc. cannot be due to diminished elimination. Aside from the migrations of the colon bacillus, it is also possible for such a degree of auto-intoxication to occur that infection by other organisms is permitted, as it would not otherwise be; and thus that which is to-day stercoræmia may become in a day or two a genuine septicæmia, vital resistance being lowered to the extent of permitting local infection that could otherwise not have occurred. The various conditions are clinically so often merged together that it is difficult or impossible to separate and identify them. Nevertheless, the fact should be taught as plainly as our language may permit that enterosepsis differs from sapræmia, to be considered shortly, in that in the one instance the putrefying material is contained within a normal cavity, whereas in sapræmia it is contained within an abnormal cavity, in either case corresponding to a *septic suppository*, varying, however, in the place of insertion, varying also in the nature of the surrounding tissues, which in the latter case are much more capable of absorption and of becoming infected than in the former.

The practical outcome of such a chapter as this is, then, to insist as strongly as possible on the preparation of patients, whenever this is feasible, for an ordeal which comprises the combined effect of anæsthesia and consequent disturbance of secretion and elimination, with loss of blood and of strength, and subsequent confinement in bed, with, moreover, all that this entails in further impairment of activities of important organs. It is not always possible, practically rarely so in emergency cases, to adopt these precautions; in which cases they must be atoned for, so far as possible, by extra attention in the same directions after the emergency is passed or has been met. In the former case, however, the functions of the skin, the kidneys, and the abdominal viscera must be regulated—the first by hot-air baths; the second by this same measure in conjunction with copious draughts of pure water, the correction of hyperacidity of the urine, and the administration of whatever drugs may be of benefit as diuretics, etc.; and the third by a course, perhaps covering several days, of gentle or active purgation, by which the alimentary canal shall be entirely emptied of all that may serve to act as a source of poisoning. In addition to this, in certain cases careful massage will dislodge from the muscles and other tissues material which they ought not to retain, and which shall be washed away, as it were, by the extra amount of fluid which this preparation necessitates. In addition, also, the activity of the heart should be stimulated, perhaps by digitalis, but preferably by that best of all tonics, strychnia, which is to be administered hypodermically in average doses of a thirtieth or twenty-fifth of a grain, morning and night. When these precautions are taken patients will successfully pass through most trying ordeals without anything which may give rise to alarm. When they are not possible, the risk of operating, even in a small way, is materially enhanced. So, too, after operations when these precautions have not been taken it is necessary to give most careful pains to atoning for their lack by such active purgation as a now reduced patient may bear—by hot-air baths, if feasible, and by the administration of such intestinal antiseptics as charcoal, naphthaline, corrosive sublimate, bismuth salicylate, salol, etc., for the purpose of reducing to the lowest possible minimum the opportunity for formation of poisons which shall disturb the proper repair of injury.

APPENDIX.

So much has appeared in the literature of the past few years with reference to so-called ptomaïnes and leucomaïnes—whose composition has been more or less accurately studied—and there have been so many references to other poisonous substances which have been more or less loosely grouped as toxines and toxalbumens, that it will probably be of great assistance to the student to at least define these terms and give some brief description of the more important substances thus classified. The original distinction between the terms *leucomaïne* and *ptomaïne* was that the former was the result of bacterial activity in albuminoid substances, occurring during the life of the individual within whose interior these processes were actively going on, while the underlying idea in the definition of "ptomaïne" is that the ptomaïnes as a class are alkaloidal substances formed by putrefaction of deal animal material. The terms, however, have been extremely loosely used, and, while it is well to maintain these distinctions so far as possible, they cannot be abruptly made, because it is known that certain of these toxic bodies may be produced under both circumstances. In a general way, however, we may still retain the idea that leucomaïne formation may be a part of badly-performed digestive function, while ptomaïne formation is connected with the death and putrefaction of the body tissues themselves, such as occur in many of the infectious diseases—*e. g.* suppuration, abscess-formation, septicæmia, gangrene, etc.

The leucomaïnes are not necessarily all of alkaloidal construction, but are more or less proteid in their chemical arrangement. They are usually divided into two groups: the *uric-acid group*, comprising *adenin, carnin, guanin, xanthin, spermin, gerontin*, etc., and the *creatinin group*, in which are found its various derivatives, *anticreatinin, xanthocreatinin*, etc. Another class of *betaïne leucomaïnes* has been formed, including *betaïne* or *oxyneurin*, which has been found in the human urine, although it seems to exist normally in the red beet and is not toxic. The most poisonous of all these leucomaïnes seems to be *gerontin*.

The *ptomaïnes* may also be divided into those which are *free from oxygen*, which persist throughout putrefactive action, and whose bacteria are not yet carefully studied. They include *collidin; parvolin; neuridin; cadaverin*, found in herring brine and putrefying human flesh; *putrescin*, found under the same circumstances; *mydalein*, which appears after several days in cadavers and is quite toxic. Most of this group are but mildly toxic.

The second group consists of *ptomaïnes containing oxygen*, whose bacteria are also, for the most part, as yet undetermined. This group forms a connecting link, as it were, between the previous group and the leucomaïnes, being found alike in dead and living tissue. It includes, among others, *neurin*, which is very toxic; *cholin*, less so; *muscarin*, first discovered in mushrooms, quite toxic; *gadinin; mydatoxin; methylguanadin; mytilotoxin; peptotoxin;* etc. Nearly all of these two groups have alkaloidal properties and form salts with acids. Physiologically, they have been divided into those having the properties of conium, atropine, delphinine, digitaline, morphine, nicotine, strychnine, veratrine, etc.

A *third group* has been made of *ptomaïnes known to be produced by certain species of bacteria*, though as yet not necessarily solely identified with them. *Tyrotoxicon* is the best known of these. It includes also *trimethylamine*.

A *fourth group comprises ptomaïnes* which have been *isolated only from pure cultures of known species of bacteria*, and includes *typhotoxin*, from cultures of typhoid bacillus; *tetanin, tetanotoxin*, and *spasmotoxin*, made from pure cultures of tetanus bacilli.

Finally, a series of *toxalbumens* has been separated by precipitation from pure and filtered cultures of various pathological organisms, which have of late played a most important rôle among therapeutic agencies. It is not possible to describe them fully, even did space permit, but they include the active principle contained in Koch's *tuberculin* and its modifications, in the *serum* prepared by Behring and others from *diphtheria cultures*, in the *mallein* prepared from cultures of the glanders bacillus, in the material made from the serum of animals rendered immune to tetanus, etc. These are for the most part precipitable by absolute alcohol from the glycerin solutions or blood-serum, in which they are held in solution, and may be produced and worked with in solid form. Their minute chemical composition is unknown.

Of all of the substances above mentioned or alluded to, it probably may be

stated without exception that they are formed as the result of the presence in the tissues or body juices of micro-organisms, without whose presence putrefaction is impossible, and without which many of the ordinary digestive processes could not be carried on. Thus, it may be made to appear that certain disease-manifestations which are in one sense the result of parasitic agents—*i. e.* of bacterial activity—are such, in effect, because of the intoxication—in one respect the auto-intoxication—produced by the peculiar activities of the alkaloidal, proteid, and albuminoid substances which are produced within the tissues as the result of their presence, be it as their excretory products or as the consequence of their agency in producing metabolism.

Very recently a large amount of most important work has been done, showing that of the various aromatic substances, including *indol*, *phenol*, *cresol*, *catechol*, etc., which are produced in consequence of the action of anaërobic organisms upon proteids and their resulting putrefactive decomposition, these substances are eliminated from the body, through the urine, if absorbed, almost exclusively in combination with sulphuric acid or acid sulphates in the form of *ethereal sulphates*. The deleterious character of potassium salts has been already alluded to, and their combination with these ethereal or aromatic sulphates is still more poisonous. *Sulphates*, as they appear in the urine, are spoken of as the *preformed—i. e.* the mineral—and the *ethereal* sulphates. It has been further demonstrated that *indican* as it appears in the urine is a combination of the conjugate sulphate of hydroxylated indol with an alkali, which may be termed *indoxyl sulphate*. Indol is a normal and constant constituent of the fæces, to which, in some part, the disagreeable odor of the latter is due. The *relation* between *indol in the intestines* and *indican in the urine* is now completely *established*, as well as that indol is the constant product of putrefaction of albuminous material in alkaline media. *Indican elimination*, then, may be regarded as an *index* of the *degree of antiseptic—i. e.* germicidal—*activity* of the digestive juices. Of these juices, the gastric juice is, by virtue of the free hydrochloric acid which it contains, the ideal intestinal antiseptic; whence it follows that the presence of *indican in the urine means absence or deficiency of hydrochloric acid in the stomach*.[1] Simon has summarized the importance of this in the most thorough way, and his conclusions may be epitomized as follows:

Intestinal putrefaction is in inverse ratio to the amount of free hydrochloric acid, and is inseparable from increased formation of indol. The conjugate sulphates found in the urine form an index of the degree of absence of free hydrochloric acid—*i. e.* of intestinal putrefaction. Indicanuria practically never occurs with normal acidity of gastric juice, save in the case of ulcer of the stomach, which is an apparent exception to this rule. Estimation of indican is a matter of consequent great importance, particularly in differential diagnosis—*e. g.* between ileus and coprostasis, where a small amount only of indican will exclude the former condition. Two possible *surgical conditions* are to be considered in their relation to indicanuria: If *resorption* of *decomposing pus* is taking place anywhere in the body, there will be *increased elimination of indican*. If there exist *stenosis* of the small *intestine, the same* will obtain. In order to get reliable and average results, it is necessary that the diet should be a normal mixed diet.[2]

A convenient and reliable method of estimating the probabilities of enterosepsis, etc. is, then, afforded by practical application of the test for indicanuria. From the facts above set forth one may learn also the advantage of administration of hydrochloric acid, probably in combination with minute doses of corrosive sublimate, as one of the preparations or methods of fortification of a patient for a surgical ordeal. (See articles by Herter and Smith, *N. Y. Med. Journ.*, June 22, 1895, *et seq.*, and by Simon, *Am. Journ. Med. Sci.*, July and Aug., 1895.)

[1] A series of careful studies by my colleagues, Drs. Stockton and Jones, has shown that these statements, while in the main correct, are not to be regarded as invariably reliable.

[2] Indicanuria should be estimated from a twenty-four-hour sample, of which a few c.c. are mixed with an equal amount of concentrated hydrochloric acid, two or three drops of a saturated solution of sodium hypochlorite or of common saltpetre being added, and, after mixture, one or two c.c. of chloroform. This mixture is then shaken and set aside. Indigo, if present, is set free and taken up by the chloroform, which is colored blue to greater or less extent. Before making this test albumen, if present, should be removed, and bile-pigments should be separated by carefully adding a solution of plumbic subacetate.

CHAPTER VII.

THE SURGICAL FEVERS AND SEPTIC INFECTIONS.

By Roswell Park, M. D.

Fever is an expression of constitutional disturbance whose most marked characteristic is elevation of body-temperature and augmentation of surface-heat.

This not being the place to go into a minute discussion of the causes of fever, it will be enough at this time to state that normal temperature of animal bodies is regulated by the heat produced from certain chemical changes, the result of the body chemistry, and for the most part controlled by the innervation of the tissues and organs, mainly of the muscles, these chemical changes consisting mainly in oxidation of tissues and elimination of carbonic dioxide. The so-called surgical fevers and infections are, for the most part, accompanied by, and often consist largely of, associated symptoms to which in a general way the name of *fever* has from time immemorial been given, the most prominent of which is the actual elevation of body temperature, which means either that heat-elimination goes on more slowly than normal or that heat-production is more active. In the surgical infections the latter is for the most part the case. Even before the first general sense of discomfort known as *malaise* some slight rise of temperature may be noted by means of an accurate thermometer. The association of the sense of extreme coldness—*i. e. chill*—with involuntary movements of the muscles is frequent, and may be noted while the temperature is steadily rising or after it has risen. If the so-called *stage of invasion*—*i. e.* rise of temperature—be gradual, chill is usually absent; on the other hand, chill is usually an expression of an acute invasion and serious disease. It is necessary, however, to distinguish between a genuine chill of this kind and *spurious chills*, which are often the result of nervous disturbance, in which the patient shivers and chatters, but in which temperature does not rise. Following chill, when it occurs, are dryness of the tongue, thirst, scanty urine, discomfort, often headache. Simultaneously with the occurrence of perspiration these symptoms subside and temperature falls, perhaps to normal. It is necessary to distinguish between high temperature and over-production of heat. The two do not necessarily go together. When temperature runs to an extreme height, we speak of *hyperpyrexia.* In these cases temperature exceeds 107° F., and there are authenticated cases, not strictly surgical, where temperature has risen to almost fabulous heights, even to 140° F. and more. In the majority of surgical fevers the disturbance is due to the presence of some extraneous material in the blood, while the severity of the fever appears to depend rather upon the nature of this material than its quantity. So it is in accordance with clinical experience that the presence of pus of recent origin within the tissues is nearly always accompanied by fever, while the old deposits of pus, which have been more or less metamorphosed (*archepyon*), never are thus accompanied. Again, the presence in the tissues of blood-clot, or infused fluid, like that from a hydrocele, or even pure water, is known to cause some elevation of temperature. Again, when certain tissues break down there are released fermentative substances similar to fibrin-ferment which have a pyrogenous action. Other ferments, such as pepsin and pancreatin, also cause fever when injected. Nearly all the products of decomposition or putrefaction have an analogous action. When we deal strictly with the surgical fevers, it may be maintained that fever is due to the presence of pyrogenous organic materials in the blood which are the result of bacterial activity, or to some ferment-like substance, or to the presence of living bacteria (Warren). With these general considerations we are better prepared to approach, first, the topic of

Surgical Fever, known also as Traumatic Fever, or Aseptic Wound-fever.

In times past, when operations were never done aseptically and when ideal wound-healing was unknown, the surgical fevers were all grouped together, and a certain amount of febrile disturbance was looked for after any injury. But with the introduction of antiseptic methods and with healing of wounds by primary union, with absence of all septic phenomena, and at present when the careful use of the clinical thermometer is common, it is noted that there is, nevertheless, a certain rise of temperature more or less quickly after an operation or reception of a wound, with fever of mild grade persisting for several hours or two or three days, and with certain other accompaniments which are usually noted along with it. This phenomenon has been carefully studied, and so completely separated from the septic fevers as to have deserved a distinct recognition under the names above given, of which the most common in this country is **surgical fever**.

So long as this fever be free from indications of septic character it is without significance and needs only symptomatic treatment. It begins usually within the first twenty-four or thirty-six hours, after which temperature may rise progressively or with a morning intermission to a height of 102°, or possibly 103° F. In children we are more likely to get extremes in this regard than in healthy adults. It will be followed by some disturbance of alimentary function, glazing or drying of the tongue, deficiency in urinary secretion, and will nearly always subside spontaneously—invariably so if cathartics, diuretics, cool sponge-baths, etc. be properly resorted to. It is usually due to the retention of blood-clot, ligatures, etc., or tissues which have been ligated and whose stumps remain; in all of which instances there is some foreign material to be removed. This means unusual phagocytic activity, perhaps temporary leucocytosis, with active metamorphosis of clot and other material; of all of which the elevated temperature is an accompaniment and expression. It is not unlikely that the antiseptic materials sometimes used have also to do with this pyrexia.

Iodoform and carbolic acid are among materials in common use which are known to be irritating and capable of producing toxic symptoms. Often after the use of the latter the urine will be discolored and will furnish the clue to the fever. In young children particularly, and not infrequently in adults, mental disturbance, even to the point of active delirium, may characterize the case. This is not always to be explained by cerebral anæmia due to loss of blood during the operation or accident, but is undoubtedly in certain instances due to drug-toxæmia, or in other cases to intoxication from materials furnished by the altered tissues.

Surgical fever of strict type may merge into a more or less continuous fever as the result of intestinal toxæmia permitted by failure to thoroughly evacuate the bowels, and this *intestinal toxæmia may be a predisposing cause of genuine septic infection.* Consequently, a surgical fever which does not disappear within two days is to be viewed with suspicion, especially if it do not subside after the administration of cathartics.

Some of these surgical fevers are accompanied by eruptions, a number of which may be due to drugs, but some of which at least are due to intrinsic poisons. Thus, carbolic acid and iodoform give rise occasionally to erythematous eruptions, and the concomitant administration of drugs like potassium iodide, quinine, anti-

pyrine, and copaiba may produce urticarial or other manifestations. Again, it is known that certain toxines—produced, *e. g.*, by the bacillus pyocyaneus—are capable of causing dilatation of the superficial vessels and various flushes or eruptions. To one of these, which dilates the capillaries, Bouchard has given the name of *ectasine*. Consequently, it by no means follows that every eruption or rash following operations or injuries is of a specific character. On the other hand, it seems to be established by numerous observers—among whom Paget is perhaps the most prominent—that surgical patients, particularly the young, are notoriously liable to infection by scarlatina; and in the experience of Thomas Smith, of 43 children whom he cut for stone 10 had scarlet fever. Consequently, in spite of the fact that a certain number of cases of eruption may have been mistaken for scarlet fever, it is undoubtedly true that in surgical and puerperal cases patients are more than usually liable to this invasion.

Erythema multiforme or similar eruptions may also be produced by the purely local irritation of an antiseptic dressing. The same is true also of *eczema*, and slight elevation of temperature is not infrequently the result of this local disturbance. These *toxic erythemas* usually occur in patches, and when due to the above cause are well localized. When, on the other hand, they belong to the medicinal eruptions, they are seen on the body and extremities as well, and usually quickly disappear. Multiform erythema may also be due to absorption of wound-secretions, and consequently may accompany surgical fever.

All these eruptions, which have but minor significance, are to be abruptly distinguished from others which are the known accompaniment of septic infection, and which serve often to complicate cases and make it difficult to assign them to their proper category. As a rule, however, *eruptions which become hemorrhagic—i. e.* purpuric—pustular, or erythematous, *are not to be regarded as innocent.*

The whole subject of surgical fever may, then, be epitomized as consisting of elevation of temperature and certain accompanying disturbances, which appear to be essentially due to the results of tissue-metabolism, including also metabolism of blood-clot, ligatures, etc. It is not a necessary nor conspicuous accompaniment of all surgical cases, and in some individuals, even after grave operations, will scarcely be noted. It is more likely to be extreme in children than in adults, other things being equal. As the result of excessive loss of blood it may be postponed. It may be complicated, and more particularly prolonged, by any one of the auto-infections, particularly that already spoken of in the preceding chapter as intestinal toxæmia, as the result of which septic infection may ensue, and that which was at first a legitimate surgical fever may thus become merged into one of the septic conditions next to be considered. In the absence of auto-infection, and with kindly and symptomatic treatment, surgical fever should quickly subside until it becomes indistinguishable, and this usually by the end of the second or third day.

Proceeding, then, in the order of pathological complexities, the next of the surgical infectious fevers to be considered is Sapræmia.

Sapræmia.

As between the various terms derived from the Greek which are applied to the different expressions of blood-poisoning, there is but little real difference of meaning. In time past there has been a great deal of misuse of all of them, and even to-day it is rare to find men using them correctly. This is not entirely the fault of their derivation, but because various conditions have been confused under one name or because various names have been applied to practically the same

condition. Conceding that cases do not always pursue a clinically typical course, it yet is possible to make out three quite distinct forms of septic infection, which, occasionally merging from one into the other, are yet ordinarily distinct enough for easy recognition, which is the more important because treatment in no small measure hinges upon their differentiation.

It is my purpose to use the term **sapræmia** here as indicating a condition which I often liken to an *intoxication produced by a supposititious septic suppository*, although the case is by no means imaginary in which this condition occurs. The term was first used by Duncan, and was largely confined, at least at first, to puerperal cases. This is its own justification, because some of the most ideal cases of sapræmia are those of puerperal origin.

In each of the three conditions comprised under the general term of *septic infection* it is not now a question of particular organisms, but of intoxication by products which are more or less common to at least several of them. In a general way, they are, for the most part, *due to the activity of the organisms already grouped as pyogenic*. Those which produce pus are easily capable of causing septic infection. In addition to these, it is probable that certain of the saprophytes or ordinary putrefactive organisms may produce the same effect. For purposes of minute study it is of interest to isolate and, so far as possible, determine the exact action of, each organism. For present purposes, however, it is neither necessary nor, perhaps, wise.

In **sapræmia** the SYMPTOMS begin promptly, depend for their intensity upon the dosage of poison, and recede quickly as soon as the source of poisoning is removed or its activity antidoted. Two illustrations of the possible causes of sapræmia will, perhaps, best illustrate its pathology. Take, first, that physiological operation of nature's own performance—namely, the act of delivery of the full-term fœtus. At the completion of this operation there is left a fresh, bleeding wound of large area which is more or less exposed to putrefactive agencies. This is reduced with the contraction of the uterine walls to a comparatively small cavity containing more or less freshly-coagulated blood. So long as this clot does not putrefy it is disintegrated inoffensively, to be discharged, at least for the most part, with the lochiæ. Let, however, germs of putrefaction enter, either during the act of labor or afterward, and linger, and putrefactive processes are set up in the clot with the prompt production of certain toxines and ptomaïnes. We have here a *septic suppository* with conditions most favorable for absorption by the containing tissues. How quickly the poisoning may show itself, and how quickly subside after removal of the putrefying clot, daily experience may tell.

Another instance: In an amputation stump a certain amount of bleeding has occurred, due perhaps to insufficient hæmostasis or to failure to ensure physiological rest after the operation. If, now, infection have occurred from failure in technique, and this clot begin to putrefy, the patient shows signs of poisoning as promptly as in the case before mentioned. Speedy recognition of the character of the case, proper drainage, antiseptic irrigation, perhaps with re-opening of the wound, will permit the cessation of symptoms almost as quickly as they arose.

Sapræmia, then, is intoxication produced by absorption of the results of putrefaction of a contained material within a more or less shut containing cavity whose walls are capable of absorption of noxious products as they form. *So long as putrefaction be essentially limited to the contained mass,* and do not spread to and involve the containing or surrounding tissues, the case is one of sapræmia. *So soon as the process spreads from the containing tissues the case merges from one of sapræmia into one of septicæmia.* That this may occur in any case without prompt intervention will be readily understood. Patients may probably die of sapræmia, though rarely, and in such case ordinarily as the result of gross neglect. Once the septicæmic process be begun, however, its spread cannot be with certainty checked, and that case which to-day is sapræmic and redeemable may, to-morrow, become septicæmic and practically lost.

The symptoms of sapræmia are not essentially different from those common to septic infection, save that ordinarily they are, at least at first, milder. There are flushing of the face, dry tongue, mental disturbance often, a considerable degree of pyrexia, while usually the whole train of symptoms is ushered in by a chill which may have been preceded only by slight malaise. These are usually followed by nausea and vomiting, with headache, and often, later, by diarrhœa or active purging. Should a case go on so far, delirium may occur, possibly even fatal coma. On post-mortem examination of a fatal case there would be few changes revealed: alterations in the blood, a failure to coagulate, some softening of the spleen and liver would probably be the only notable changes.

Treatment.—For a condition so easily recognized treatment should be prompt, and will then be almost always effective. It is all summed up in the urgent advice to remove the cause, although this may not always be easy of performance. In the first case supposed—*i. e.* one of puerperal sapræmia—the treatment would be to empty the uterus, to give vigorous antiseptic douches, to irrigate as often as necessary, to prevent offensive odor to the discharge, and to combat the general signs of poisoning by plainly indicated measures. Heart-depression should be overcome by the use of diffusible stimulants and by hypodermic injections of strychnia in doses of $\frac{1}{25}$ grain or more. The *bowels should be promptly unloaded* by a mercurial, followed by a saline cathartic. Suppression of urine may be treated by venesection and by hot-air baths or sweats; diuretics should also be prescribed, and fluids should be administered copiously. If the patient be very restless, an opiate should be promptly given; if delirious, necessary restraint should be resorted to.

Essentially the same measures should be carried out in a surgical wound, or in case of compound fracture, or any injury where retained material may be undergoing changes already alluded to. General measures should be the same. Our forefathers were certainly wise in advising the use of *purgatives* in these cases, for nature often sets us the example in the shape of watery and most fetid evacuations, showing that there is much retained whose evacuation should be hastened.

By such measures as these the average case of sapræmia can be promptly and successfully combated so long as it be still such, and so long as putrefaction has been limited to material not a part of the living tissues, even if confined within them.

Septicæmia.

According to the views thus enunciated, the difference between sapræmia and septicæmia is not one of character so much as of location. *In septicæmia the putrefactive action is no longer confined to material enclosed by, yet not of, the tissues themselves, but has spread from this to the surrounding living cells*, which are now being attacked by bacterial enemies; in other words, we deal now with *infection of living tissues rather than with mere intoxication.* This is now a *progressive invasion* of tissues by continuity, *with* a constantly proceeding systemic *intoxication* by poisons produced ever in larger doses. So rapid may this action be—as may be seen in malignant diphtheria, for instance—that the individual speedily succumbs before abundant evidences of abscess or local gangrene appear. On the other hand, providing that the toxic action be less pronounced or the patient's vitality more enduring—*i. e.* his tissues more resistant—abscess, phlegmon, or local gangrene may result, the destruction of tissue being limited to the environs of the parts first involved.

While septicæmia, then, may be a direct continuance of an original sapræmia, it is not intended to intimate that it may not originate *de novo;* that is, *many cases may begin as a pronounced septicæmia from a local infection.* This is the case, for instance, with the majority of dissecting wounds, etc.

Symptoms.—In septicæmia we have a period of incubation, usually two or three days at least, often longer. If this follow an operation, the mild fever which would indicate the slumbering fire is usually regarded as merely surgical fever. But when, instead of subsiding, this rises and is followed by prostration with alimentary disturbance, loss of appetite, headache, etc., quickly followed by those general symptoms which we speak of as typhoidal, the alarm is sounded and should be quickly heard. Usually, but not always, there is a preliminary or *premonitory chill*, after which prostration will be much more marked than before. The severity of the general symptoms can in no degree be foretold from the size, location, or character of a wound. The character of the fever is essentially continued, usually with morning remissions. Gussenbauer has called attention to a class of cases in which subnormal temperature is caused by the absorption of ammonia compounds. To these he has given the name *ammoniæmia.* This condition may be seen oftenest in connection with gangrenous hernia, and has even been mistaken for shock (Warren).

In septicæmia proceeding from infection of a visible portion of the body there are usually seen evidences of *lymphangitis* and *perilymphangitis*—of course of septic character. These will be evidenced by tender and purplish lines, extending subcutaneously along the course of the known lymphatics or in connection with the more prominent subcutaneous veins. The *lymph-nodes*, into which these visible vessels as well as the deeper ones empty, become quickly *enlarged and tender;* the whole lymphatic system participates; the *spleen* in aggravated cases becomes notably *enlarged*, and even the bone-marrow more or less involved. *Diarrhœa* is commonly an early but controllable symptom. A hæmatogenous icterus of mild degree is another frequent accompaniment. The conjunctiva becomes plainly discolored, and the skin slightly so. Should

the blood be examined, marked *leucocytosis* will be noted, and should cultures be made from it, in many instances at least the organisms at fault can be detected and recovered from it. The vigor of the heart-muscle is seriously impaired; the *pulse* becomes *rapid* and *weak*. In scarcely any form of septic infection is this more prominent than in diphtheria; and microscopic examination shows the rapid disintegration of the cells of the heart-muscle, as well as those of other parts of the body, even to the almost complete molecular disintegration of the nuclei. Erythematoid, pustular, even hemorrhagic *eruptions* are met with upon the skin, some of which are probably to be explained by thrombosis of the dermal capillaries. Certain *complications* are not infrequent, among which inflammations of the pericardium and endocardium—*e. g.* ulcerative endocarditis—are frequent. As the case becomes aggravated temperature rises irregularly; the hot, dry skin becomes cold and clammy; prostration and indifference more marked; diarrhœa more colliquative; icterus more pronounced; urine more reduced in quantity or suppressed; and these symptoms are succeeded by indifference, mental apathy, stupor or delirium, and finally death, patients being comatose and collapsed.

While these are the general indications of septicæmia, the *wound* or site of injury has undergone *changes* which are also *characteristic*. They comprise, first, the *œdema and redness of wound-margins*, which may be seen even in sapræmia, followed by increasing *tumefaction*, escape of *foul-smelling discharge*, and finally by *sloughing and gangrene* of the parts involved. On microscopic examination the capillaries are filled with infective thrombi and vessel-walls infiltrated with micro-organisms, which abound also in the lymph-spaces. Bacterial infection can be traced in microscopic sections from the infected area, from the point in the neighborhood of the wound where microbes infest the tissues, to points remote from it, where they are sparsely found, if at all. The same evidences of infection may be traced along the lymphatic vessels, and often the veins.

The POST-MORTEM EVIDENCES of septicæmia are plainly indicative on first sight: the blood is of a consistency like tar, does not coagulate; evidences of putrefaction are plain to sight and smell; the serous membranes, particularly the pia mater, are often extravasated; the muscles are discolored and of a darker hue than natural; œdema of the lung is frequent; the intestines reveal a gastro-intestinal catarrh, the duodenum and rectum particularly showing punctate hemorrhages; the spleen is darkened, enlarged, and very much softened; the liver shows similar signs, less marked, and at times an emphysematous condition due to putrefactive gases. Cultures can be made from all the fluids and tissues of organs thus affected. It is also of the greatest importance to emphasize that such material is *powerfully*, often fatally, *infectious;* and some of the worst forms of dissecting wounds and most rapid instances of *fatal infection* have come from carelessness in making these *post-mortem examinations.*

So far as concerns the character of the wound, which is most likely to be followed by septicæmia, there is but little to be said. In a general way, wounds made by infected tools, the butcher's knife, the anatomist's scalpel, etc., are the most dangerous, and too often those which are so small as to either escape observation or be considered too trifling to call

for treatment. All forms of phlegmonous erysipelas, many cases of gangrene following frost-bite, nearly all instances of traumatic gangrene, most cases of carbuncle, and, in fact, all similar lesions, are extremely likely to be followed by septicæmia. The so-called spontaneous cases have an equally infectious origin, though one which is concealed. In unrecognized instances of appendicitis, for instance, and in many other conditions, although the path of infection may not be easily traced, it is, nevertheless, always present, and can be found if diligent enough search be made. Too often the nasal cavity, the tonsils, the teeth, the middle ear, the deep urethra, and the rectum are overlooked as offering possibilities for septic infection which may follow this general type.

TREATMENT.—This must be both local and general. Local treatment should consist in complete and absolute removal, so far as may be possible, of the active cause. This will comprise the reopening of wounds, evacuation of clot, cutting or scraping away of sloughs and gangrenous tissue, with cauterization of the exposed living tissue, in order that absorption may not be rather promoted than prevented, and will often include such heroic measures as the amputation or extirpation of a part. For tissues which are not too completely riddled by disease and lost beyond possibility of redemption *continuous immersion in hot water* offers often the best possible prospect. By it putrefaction seems checked, the separation of dead from living tissues is accelerated, relief of pain or discomfort is afforded, and prompt disinfection of material which is foul and infectious is guaranteed. The best local application known to me is the mixture, resorcin (5 parts), ichthyol (10 parts), ung. hydrarg. (40 parts), and lanolin (45 parts), already mentioned in Chapter III.

When powerful caustics are needed for the purpose above indicated, one may take his choice as between the actual cautery and some powerful chemical agencies, among which pure bromine and nitric acid rank as the strongest; while if weaker ones will suffice, they may be found among the zinc-chloride solutions of varying strength, pure carbolic acid, etc. To a sloughing wound where immersion is impracticable, powdered charcoal may be applied, which will be the next best substitute, since charcoal has the property of absorbing gases. There may be mixed with it iodoform, naphthaline, etc.; or, as I have often recommended, granulated sugar, which is of itself a most excellent and efficient antiseptic. A mixture of one-third sugar to two-thirds charcoal, with 5 per cent. of naphthaline, makes a very excellent deodorizer and antiseptic for local application.

The *general treatment* of septicæmia is, in the main, *stimulant* and *tonic*. Fever is not now to be treated with arterial sedatives nor often with antipyretics. It is an expression of poisoning, and its too prompt suppression prevents both the recognition of the intoxication and the measure of its degree. Pyrexia, then, is best combated with cool sponge baths and stimulant measures of a general character. The principal reliance must be upon *nutrition* and *stimulants*. Assimilation must be impaired when gastro-intestinal catarrh is so prominent a feature as it is in many of these cases. Consequently, the simplest and most assimilable food, often that which is predigested, should be administered. Milk, eggs, beef-peptonoids, and fruits are among the most appropriate. Of all the stimulants and tonics which the materia medica affords, the two best are *alcohol* and *strychnia*. Strychnia is preferably administered hypodermically in doses of $\frac{1}{25}$ grain, subcutaneously, from two to four times a day, or even oftener. Heart-depression is best

combated by this measure, or by *quinine* in large doses, while digitalis and atropine may be added if necessary. For internal use *alcohol* is, *par excellence, the remedy.* This is administered now in doses only to be measured by their effect. In fact, the administration of alcohol in these cases is a matter of *effect*, and *not of dosage.* It is sometimes difficult to administer it in necessary amounts. The purest whiskey or brandy is of course the best form in which to give it. Owing to the difficulty in many places of obtaining these liquors unsophisticated, I have often resorted to the practice of administering pure alcohol, sufficiently diluted and flavored to make it palatable. This may be given with milk or in any other way. Should the stomach refuse to deal with it, it should be given by the rectum. It may be safely given in doses just short of producing intoxication. Aside from being a stimulant to the patient, it is the least harmful of substances which may be introduced as antiseptics, the relations between its absolute and relative toxicity being safer than with almost any other drug. Alcohol given in this way is life-saving: when not so given, one may fail to get its possible benefits in serious cases. Aside from these measures, the intestinal antiseptics should be administered, among these being corrosive sublimate, $\frac{1}{100}$ grain every three or four hours, salol in large doses, bismuth salicylate, or naphthaline—any or all of these in connection, preferably, with powdered charcoal. Intestinal pain and frequency of stool can be more or less controlled by opium, while real disinfection of the alimentary canal is only to be accomplished by the above remedies, in connection perhaps with flushing of the colon with saturated boric-acid solution or something of that kind. Pain is to be controlled by morphia administered subcutaneously.

PYÆMIA.

The derivation of the term "pyæmia," which came into general use in 1828, is misleading. Although septic fever always accompanies suppuration, it is not the case that pus, as such, circulates in the blood, as the term pyæmia implies, the error having arisen originally from mistaking the contents of breaking-down thrombi for pus from ordinary sources. While a recognition of the etiology of the disease is new, the disease itself has been recognized for many centuries. Accurate study of it is due to recognition by Cruveilhier that septic phlebitis means coagulation of blood within the veins, and of Virchow's investigations of thrombosis and embolism. (See Chapter II. for these subjects.) Virchow's term, *ichorrhæmia*, should not be accepted as a substitute for the term pyæmia, unless the essentially underlying idea of metastatic abscesses is understood to be a part of it.

Pyæmia is only met with in connection with suppuration; so far as known, never without it. In those cases which appear to be free from suppuration pus will be found on careful search. *Pyæmia may be described as septicæmia plus thrombotic and embolic accidents which lead to distribution of infectious material to all parts of the body.* This distribution is, for the most part, made by the blood-vessels, although to some extent the lymphatics undoubtedly participate. When pyogenic organisms reach blood-vessel walls they often set up a *mycotic phlebitis*, which, by virtue of the coagulating blood, becomes quickly what is known as *thrombo-phlebitis.* Infection proceeding through the vessel-walls, the endothelial lining is loosened, while to these rotting spots

leucocytes adhere and coalesce into a more or less homogeneous mass. This so-called *white thrombus* becomes also infected with bacteria: portions of it, loosened and dislodged, are carried by the returning blood-stream to the right side of the heart, whence they are distributed through the lungs. Dislodgement may be by mere force of the blood-stream, or may be assisted by movements of the part or handling of the same. These particles of thrombi are loaded with the infectious organisms which have begun the disease, and wherever each one settles a reproduction of the original thrombo-phlebitis is quickly produced. In this way numerous infected thrombi are formed within the vessels of the lungs, which, again, loosen, and are now swept into the left side of the heart, whence they are distributed with arterial blood in all directions. While it is true that they are probably equably distributed, it is also positive that certain tissues seem more capable of lodging and being attacked by the contained organisms than are others. When it is once appreciated that each particle of infected clot is capable of setting up, either in the lungs or in the other tissues, upon the second distribution, other abscess-formations analogous in etiology to that from which came the first disturbance, then, and then only, is the fundamental idea of **metastatic abscess** fully impressed. The term **metastasis** may be regarded as *synonymous with transportation*, and metastatic abscesses are those produced by transportation of infected particles from one part of the body to another. Wherever they lodge similar trouble will result, providing only that the patient live long enough. Contiguous minute metastatic abscesses quickly *coalesce*, and in this way large collections of pus are formed. The blood also contains organisms not attached to thrombi, and from the blood of the pyæmic patient cultures can be made at almost any time. Until this be done it will be virtually impossible to incriminate any particular organism as the one at fault. *Thrombo-arteritis* is the equivalent in the arteries of thrombo-phlebitis in the veins, and is accompanied by the same detachment of endothelium, adhesion of leucocytes, etc. Whenever such a lesion occurs in artery or vein, coagulation-necrosis takes place and suppuration occurs around it. The metastatic abscess is thus the result of breaking down of this affected tissue, and is often spoken of as *miliary abscess*. Particles of infective thrombi cling also to the valves of the heart, and a ***septic endocarditis*** may result.

Per contra, on the roughened valve of a previously diseased heart organisms which may be temporarily circulating in the blood may cling; and the possibility of an acute infectious endocarditis as the result of previously disturbed valve-linings, in connection with possible infection from the intestinal canal or other tracts, cannot be denied.

There is no organ in the body nor tissue in which we may not find these metastatic abscesses. The only conditions, however, under which ordinary pus is found floating in the blood is when an abscess has broken directly into a blood-vessel. Pus is more likely to be found in the lymphatic vessels than in the arteries or veins. This is particularly true in puerperal pyæmia, when pus will be found which has migrated along the lymphatics in the broad ligaments of the uterus.

The possibility of *so-called spontaneous or idiopathic pyæmia* is occasionally discussed. This means nothing more than a pyæmia whose cause is concealed. The explanation will be found sometimes in

an acute infectious osteomyelitis, sometimes in ulcerative endocarditis, or inflamed appendix or other portion of the peritoneal cavity. Again, it may proceed from middle-ear disease, in which there is so little discharge as scarcely to attract attention. Thus, causes which predispose to suppuration, which have already been discussed in Chapter III., come into play here, and the influence of exposure, fatigue, starvation, etc. is not to be ignored in furnishing an explanation for the so-called idiopathic cases.

In the majority of instances, however, pyæmia follows surgical operations and injuries, among which are compound fractures, deep injuries with small superficial evidence thereof, compound injuries of the skull, and injuries by which veins are exposed. Inasmuch as the typical pyæmic manifestations require a certain length of time for their development, the onset of this disease is more delayed than in the case of septicæmia. While the case may be manifestly one of septic infection of unrecognizable type, the characteristic indications of pyæmia seldom appear in less than ten days, and frequently not for several days longer.

Symptoms.—The symptoms of pyæmia do not essentially differ from those indicating the other septic infections already mentioned. The principal difference is in the *frequency of chill* and *range of temperature*. *Chills* are much more *common* at the *inception* of the condition, and much more *frequent* throughout its continuance, than in other septic conditions. The chill may be slight or assume the proportions of a rigor, and each chill is followed by colliquative sweat and exhaustion. In other words, chills, which are infrequent in septicæmia, are common in pyæmia. There is reason to think that with each fresh distribution of emboli we have one or more chills as the objective evidence thereof. Distinctive also in large measure of pyæmia is the *temperature curve*, which much resembles that of intermittent fever, without the regularity of change characteristic of malarial fevers. It is without regular remissions, and has been spoken of as irregularly intermittent. The first rise is abrupt and usually excessive, while with each fresh chill or series of chills similar abrupt alterations will be noted. These occur so frequently and fluctuate so irregularly that in order to note them accurately the temperature should be taken at least every two hours. With all this irregularity, the temperature never drops to normal, except possibly toward the last.

As the lungs fill up with the first crop of infected emboli, and the first series of metastatic abscesses form there, there is more or less *dyspnœa* and sense of oppression: there may be also *pulmonary complications*—pleurisy, bronchitis, etc., even pulmonary œdema. Quite frequent it is to have expectoration of frothy and discolored sputum; occasionally there is blood in the sputum. A peculiar *sweetish odor of the breath* has been noted by many observers in this disease, and is supposed to be idiopathic and characteristic. With the dispersal of the second crop of emboli from the lungs we are now quite likely to get *icterus*, with, later, evidence of *metastatic abscess in the liver*, where we find large collections of pus as the result of coalescence of small abscesses. The sensorium is not so affected in pyæmia as in septicæmia, and in the former disease patients are more likely to be alert and active in

mind. General *hyperæsthesia* and *restlessness* are common. Colliquative sweats are also a feature distinctive rather of pyæmia. There is the same liability to *eruptions*, etc., which may mislead or complicate the diagnosis. There is undoubtedly a dermatitis met with sometimes in pyæmia, the lesions assuming a papular or pustular form, due to local infections of the skin. Purpuric spots are also seen, and vesication is not infrequent. Within the mouth *sordes* collect quickly upon the *teeth or gums;* the *tongue* becomes dry and brown and heavily coated. Diarrhœa is less common in pyæmia. The urine is usually scanty and high-colored, containing solids in excess; albumen is sometimes found therein, as well as peptone. The presence of *peptone in the urine* is probably an indication of the breaking down of pus-corpuscles in various parts of the tissues.

One most significant objective evidence of pyæmia is met with in the *metastatic collections of pus within the joints*, which occur relatively early, and which, if multiple, may surely lead to a correct diagnosis. One of the earliest joints to be involved is the sterno-clavicular, although none of the joints are free from possibility of invasion. The articular serous membranes seem to have the property of carrying and holding the infective thrombi better than almost any other tissue in the body. The *pyarthrosis* of *pyæmia* is for the most part painless, yet implies loss of function of the affected joints. The distention of these is usually evident to the eye, the fluctuation pronounced, tenderness not extreme, but the swollen part merges out into tissues which are œdematous and reddened. When pain in the limb is extreme, it is usually because of metastatic abscess within the bone-marrow cavity. In other words, we now have a *metastatic osteomyelitis*.

In all cases of pyæmia prostration is marked, yet the pulse is seldom so weak as would be anticipated, at least until toward the last. As cases progress from bad to worse *subsultus tendinum* is often noted.

The *appearance of the wound* or site of operation, if such there be, does not differ essentially from that already described under Septicæmia. There is usually, however, *less discharge*, granulations are *smoother and dryer*, and, if tissues be gangrenous, they are not so offensively wet and nasty as in the other case. *Evidences of thrombo-phlebitis and lymphangitis* will proceed from the wound toward the body, as in other instances of septic infection.

Prognosis.—Prognosis is almost always *bad*. While recovery may occasionally follow where metastatic infiltration has not been too general, the ordinary case of pyæmia will die within twelve to fourteen days after its recognition. In other instances the entire process is much slower, and isolated cases occur which entitle us perhaps to make a separate designation for *so-called chronic pyæmia*, which differs but little from the acute form, save in the extreme slowness with which the entire programme is gone through. The student should never be unwilling to recognize pyæmia, as such, simply because he finds no evidence of infection from without—*e. g.* no wound. I have known a fatal case of pyæmia from a suppurating soft corn which was not discovered during life. Cases are also known from *peridental abscesses*, etc. which had been overlooked. Death is the result of tissue-destruction and

septic intoxication. It is brought about, however, largely by sheer exhaustion.

Post-mortem Appearances.—In the vessels these consist essentially of *thrombosis*, excellent examples of which may be seen, for instance, in the cranial sinuses and in the large veins. Aside from these, with the *enlargement and softening of the spleen*, the *liver*, and *lymphatic structures*, already described under Septicæmia, the principal objective evidences consist in the discovery of metastatic abscesses in many or all parts of the body. As stated above, there is no tissue nor organ in which they may not be found. The mechanism of their production has been already described. *Infarcts* may also be met with, in the kidneys especially, the liver and spleen as well, and indicate areas already cut off from blood-supply by thrombo-arteritis, in which abscess-formation would have occurred had time been given. In the liver large abscesses may be found; joint-cavities may be filled with pus; the lungs are usually the site of innumerable small abscesses. The other post-mortem changes commonly noted are not difficult of explanation, but are not so characteristic nor pathognomonic as to call for further mention. In a joint which has become filled with pus there has usually been loosening of the cartilage and more or less disorganization of all the joint-structures, which appear to have undergone most rapid ulcerative destruction and putrefaction.

Treatment.—Treatment of pyæmia is in large degree unsatisfactory. That which used to be the terror of surgeons in the preantiseptic era is now, thanks to Lister and others, almost abolished. Pyæmia is a rare disease in modern surgical practice. Its possibility should be borne constantly in mind, however, and the necessity for careful antiseptic or for a rigid aseptic technique is in large degree based upon fear of pyæmic consequences.

When once established, the disease is to be treated on nearly similar lines to those laid down for septicæmia. Amputation or extirpation of the part from which infection has first proceeded may be of avail, though usually it will prove too late. Among the most successful, yet radical, of measures for surgical treatment of this disease is to expose the infected area, freely open the involved veins, and either excise them or scrape them out and thoroughly disinfect them. This treatment has been particularly successful in certain cases of cranial infection following middle-ear disease, etc. (For more with regard to this work in a special location consult Volume II. Chapter I.)

That there should be complete disinfection of the infected area, and that continuous immersion in hot water, if practicable, should be practised, are just as important here as in other septic cases. Metastatic abscesses should be opened and freely drained, and every accessible collection of pus should be evacuated, either by the knife or perhaps with the aspirator needle—*e. g.* in the liver.

So far as medicinal treatment is concerned, it is practically the same as in septicæmia, while the surgeon's mainstays will be alcohol and strychnia. These, with cathartics and intestinal antiseptics, will praccally sum up the drug-treatment, the surgeon meantime not neglecting the matter of nutrition, crowding it in every assimilable form.

Erysipelas.

Erysipelas is an *acute infectious disease characterized by its tendency to involve the skin and cellular structures, to extend along the lymphatic vessels, to involve wounds and injuries under certain conditions, accompanied by more or less fever of septic type, leading frequently to septic disturbances of profoundest character, yet tending in the majority of instances to spontaneous recovery.* It has been observed probably from prehistoric times, but has not found a proper description nor appreciation until perhaps within the past century. It occurs in so-called *traumatic* and *idiopathic* form—which latter simply means that the site of infection is not discovered—and also in a *virulent* and *contagious* type, which leads to the appearance of a large number of cases over a widespread area of territory; in other words, it often appears in the *epidemic* form. On account of the characteristic reddening of the skin it goes by the suggestive name of *the rose* among the German laity. It may assume the type of an infectious dermatitis, subsiding without suppuration, or a similar lesion of exposed mucous membrane may be noted, or, occasionally, its virulence seeming greater, its lesions are met with in more deeply-seated parts, accompanied by suppuration or even gangrene, and it is then spoken of as of the *phlegmonous type.* In a small proportion of cases the infectious organism appears to be transported from one part of the body to another, and thus we have *metastatic* expressions of this disease. The most common expressions of this are seen in erysipelatous meningitis after erysipelas of the face or scalp, and erysipelatous peritonitis after the disease has manifested itself on the truncal surface. It is of a type which makes itself almost interchangeable with puerperal fever; and in time past, when epidemics of erysipelas have involved certain states or areas, it has been noted also that nearly every obstetric case developed puerperal septicæmia.

Etiology.—There is more than passing interest connected with this last statement. It is now definitely established that the infectious organism is a *streptococcus* which is most strongly allied to, if not identical with, the streptococcus pyogenes, the ordinary pyogenic organism of this form.

This is hardly the place to discuss the minute questions of their identity or differences. It is proper to state, however, that most forms of puerperal septicæmia are due to one or the other of these streptococci, and if they are essentially identical, the interchangeability of the two diseases is thus easily explained. The epidemic features of such cases, then, are no more difficult of explanation than those in any other epidemic, and the puerperal fever of these experiences is essentially a puerperal or uterine erysipelas.

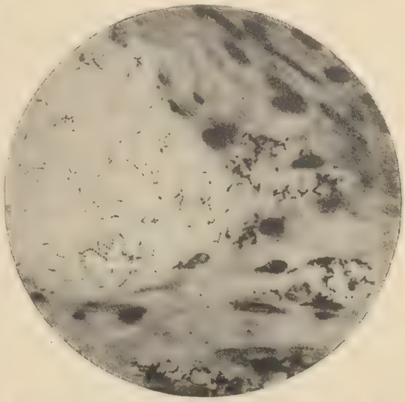
The specific organism has been separated, studied, and its rôle assigned unmistakably by Fehleisen, and the organism is frequently spoken of as *Fehleisen's coccus.* Preserving always its morphological characteristics, it acts, as do many other pathogenic organisms, within wide limits in virulence. Cultivated from some cases, it scarcely seems infectious, while from others it is violently and quickly fatal.

The experimental evidence of the specificity of this coccus is now complete, because it has been intentionally used in a number of cases to deliberately provoke the disease in the endeavor to modify the course of certain malignant tumors. (See Treatment of Carcinoma and Sarcoma.) Each coccus varies from 0.3 to 0.4 μ in

diameter, and the organisms collect in chains, as do other streptococci. The organisms divide by fission and are readily stained.

PATHOLOGY.—The disease manifests a remarkable tendency to travel *viâ lymphatic routes*. So long as it is confined to the skin and superficial tissues, we have the general appearance of an acute dermatitis. When it migrates deeper, it nearly always leads to suppuration, which is another reason for thinking that the streptococci of erysipelas and of pus-production are the same. In the affected and infected area the minute lymphatics will be found crowded with the cocci, which are seen much less often in the small blood-vessels; also in the tissues beyond the apparently infected area they may be found dispersed less freely. The bacterial activity seems most active along the advancing border of the superficial lesion. Here the phenomena of hyperæmia and phagocytosis are most active. Even in the vesicles that are characteristic of the disease the organisms may be found.

FIG. 32.



Streptococcus erysipelatis: section of skin showing invasion by cocci; × 500 (Fränkel and Pfeiffer).

All the *discharges* from this region are *infectious*, often in the highest possible degree, and extreme caution should on this account be observed in any operation, even in dressing such cases. A finger pricked by a pin from a dressing may subject the individual to loss of life. The *dressings* containing the discharges should be promptly *burned* immediately upon their removal.

The most frequent path of infection is through some wound, and so thoroughly recognized is this fact that it is now a duty upon first recognition of a case of erysipelas to separate it from all surgical cases, or, if the erysipelatous patient cannot be isolated, to remove from his proximity all other wounded individuals.

Infection through the respiratory or alimentary tracts is always theoretically possible, and it is quite certain that the nose and pharynx are the port of entry for the germs in at least a certain number of cases of so-called spontaneous facial erysipelas. In other words, it is not likely that the disease can ever appear without some surface lesion which permits infection; but this surface lesion is often concealed, or may even be healed before careful inspection is permitted, so that it is by no means always easy to trace infection. Vaccination is a little operation which is frequently followed by infection of this character. On the absolutely unbroken surface of the normally healthy individual it is not likely that infection would occur. *Erysipelas of the new-born* is simply another expression of the same disease, infection being permitted through the umbilical cord or through contaminated discharges which may have entered the nose, mouth, eyes, etc. during the process of parturition. It differs in no other sense from the other cases, is due to ignorance or neglect in most instances, and is very fatal. Alcoholism, scurvy, exhaustion, etc. are conditions which seem to predispose toward infection. It is known that certain individuals are liable to almost annual recurrence of the disease. This is hardly to be explained on any known basis, though it has been suggested that their lymph-spaces are larger than is normal.

The erysipelas which evidently follows injury, however slight, is always spoken of as *traumatic*. The term "idiopathic" or "spontaneous" should be restricted to those cases in which the path of infection is not discovered, and should be accepted then as simply an expression of ignorance in this regard.

Symptoms.—With the exception of the local appearances, they are essentially the same in both of the above-mentioned forms. The most characteristic feature of the disease is the *dermatitis* with its peculiar *roseate* hue, which it is impossible to describe in words. In tint it differs but very little from that noted in certain cases of erythema. It is, however, accompanied by an infiltration of the structures of the skin, so that the area which is reddened is at the same time elevated above the surrounding surface. Its edges are often irregular. As exudate takes the place of blood in the tissues, the red tint merges into a yellow. At this same time there is more induration of the skin and more tendency to pit on pressure. Vesication of this involved area is now frequent, the vesicles often coalescing and forming large blebs and bullæ, which fill with serum that may, later, become discolored or purulent. When exposed to the air, unless the tissues become gangrenous, this serum usually evaporates and forms scabs. This disturbance of the skin is always followed after a number of days by desquamation. This infectious dermatitis shows a constant tendency to spread in all directions. Its most characteristic appearances are limited to the margin of the enlarging zone, while at the same time in its centre there may be evidences of recession of the disease. If it commence in the neighborhood of a wound, it will probably spread in all directions from it. Beginning in the face, it spreads upward usually; in the trunk, in all directions; while if on the extremities it tends to migrate toward the trunk. *Wandering erysipelas* is a term often applied to these phenomena. The metastatic expressions of the disease have been already alluded to.

When this infection attacks a recent wound the local appearances are not essentially distinct from those already spoken of under Septicæmia. The wound-margins separate to a greater or less extent, the surfaces slough, and a very characteristic sero-purulent discharge occurs. Granulating surfaces usually become glazed—often covered with a membrane resembling that of diphtheria; deep sloughs may occur, undermining of wound-edges, even hemorrhages, from destruction of vessel-walls. In rather rare instances, however, under the influence of the microbic stimulation granulations proceed even faster than normal.

Whether, now, the disease proceed from an evident injury or not, the *constitutional* symptoms vary but little. There is usually a period of *malaise* with *nausea*, followed by evident alimentary disturbance, coating of the tongue, elevation of *temperature*, sometimes with, sometimes without, occurrence of *chill*. Within a short time complaint of pain or unpleasant sensation will lead to examination of the area involved, when the above symptoms will be noted along with evidences of *lymphangitis* and enlargement of lymph-nodes. When chill occurs it is very promptly followed by pyrexia. Temperature fluctuates according to no known principles, with a tendency to assume the remittent type. When the disease subsides spontaneously, it is by a gradual process of betterment, with gradual subsidence of temperature. In other instances the consti-

tutional symptoms assume more or less of the *septicæmic* or *typhoid* type, and it is easily appreciated that the patient's condition is practically one of mild septicæmia, which often becomes serious, sometimes even fatal.

When, now, the disease assumes the *phlegmonous* type, the constitutional symptoms become more and more typhoidal and septicæmia becomes most pronounced. Locally, exudation goes on to the point of threatening, even of actual gangrene, unless tension be relieved by incisions. Pain is usually intense, partly because of confined exudates beneath unresisting structures. More or less rapidly the local and constitutional signs of pus-formation are noted, and unless these be observed and acted upon early we will have not only suppuration, but more or less actual gangrene, so that not only pus, but sloughs of tissue, will be discharged through the incision, or will, when this be delayed, make their escape by death of overlying textures.

Everywhere it seems to be the cellular tissue which becomes most easily involved in the erysipelatous conflagration. Accordingly, muscles are separated from each other, and bones may be laid so bare as to lead to subsequent necrosis. When joint-surfaces are first exposed we usually get a prompt invasion of joint-cavities and sometimes extensive destruction, which compromises not only the joint itself, but the individual's life. Under these circumstances he does well if he escapes with ankylosis. In these cases we get perhaps our best expressions of so-called purulent infiltration and burrowing of pus. Large areas of skin may in this way be separated, to subsequently slough. There is now no tissue in the body which is exempt from destructive attacks of this character. Excellent examples of phlegmonous erysipelas are seen in dissecting wounds of the fingers and hands and those produced by instruments in butcher's shops. A trifling prick or abrasion in the dissecting-room may lead to most rapid involvement, more or less destruction and loss of function, and suffering which can scarcely be told in words. Pain in these cases is due to excess of exudation and tension. It is well that one familiarize himself thoroughly with the course of tendon-sheaths and bursæ, about the hands and fingers especially, in order that he may appreciate the direction in which pus is most likely to travel.

In those parts where tissues are loose, in either form of erysipelas, exudation may be so copious as to be disfiguring, if not dangerous. Thus, the eyelids become so infiltrated that it is impossible to open them, and the nostrils are more or less occluded; the ears also show marked tumefaction; while about the external genitals especially the puffing of tissues is most distinctive. Here, too, gangrene perhaps most often threatens, and here it is necessary to make incisions early to avoid dangerous tension.

In all *phlegmonous* cases there is practically coincidence of septicæmia, already described, and of the local appearances above noted. In proportion to the extent of the lesion in these phlegmonous cases, and failure to afford relief, will be the opportunity for septic intoxication.

Even the mucous membrane does not always escape, and in the nose, the pharynx particularly, but even in the vagina and rectum, a distinctive erysipelatous lesion may be met with. The disease may travel from the pharynx through the nose to involve the face, or through the Eustachian tube to the ear and thence to the scalp, or *vice versâ*. *Erysipelatous laryngitis* is most to be feared on account of œdema of the glottis, which would be quickly fatal unless promptly overcome by intubation or tracheotomy. An infectious exudation into the lungs is also known following erysipelas, and has been considered an *erysipelatous pneumonia*. The cellular tissue of the orbits may also be involved, in which case we will have abscesses which should be opened early; while, again, the parotid and other salivary glands may become involved, usually in suppuration.

Many cases are accompanied by much *gastric irritation*, which it is

difficult always to explain. Ulcers are sometimes found in the intestines, as after burns. These usually give rise to bloody diarrhœa. The cerebral symptoms may be simply those of delirium from irritation or of meningitis from infection. Strange phenomena have followed the disease in certain instances—cessation of neuralgic and of vague unexplainable pain, improvement in deranged mental condition, spontaneous disappearance of tumors, etc. Advantage has been taken of this last in the treatment of these cases. (See Cancer.)

In time past the supervention of so-called *rheumatoid* complications during erysipelas has been noted by various clinicians, and the *coincidence of erysipelas and arthritis* has been long recognized. That which previous observers have spoken of as complications of rheumatism and gout, or as arthritic erysipelas or suppressed gout, etc., must be explained by the fact, already stated, of the liability to involvement of the synovial membranes underlying superficial areas already involved in the infectious process. Cardiac lesions, especially *endocarditis*, are also among other complications. Joint-complications may be also purely metastatic, the fresh lesion to be explained after the same manner as the metastatic abscess of pyæmia. Thus, of 130 soldiers in hospitals suffering from gunshot fractures, who had been seized with erysipelas, pus was found in the interior of joints at least 5 times. In each case there was also superficial redness.

It is quite likely that some of the worst forms of phlegmonous erysipelas are due to *mixed infection*. It is known, for instance, that to inject the bacillus prodigiosus together with the streptococcus of erysipelas will greatly enhance the virulence of the latter, so that reaction may proceed even to gangrene.

Post-mortem Appearances.—These are not distinctive, but are a combination of local evidences of suppuration and gangrene, with the deterioration of the blood, the softening of the spleen, etc., which are characteristic of septic poisoning. Only in the skin, and then under microscopic examination, can any distinctive pathognomonic appearance be made out. This will consist of the crowding of the lymphatic vessels and connective-tissue spaces with cocci, in the evidences of rapid cell-proliferation, in the quantity of exudate, in vesication, sloughs, etc.

Diagnosis.—Diagnosis of erysipelas has mainly to be made from various forms of erythema, from certain drug-eruptions, and perhaps from other forms of septic infection which do not assume the clinical type of erysipelas. The gastric symptoms of this disease are sometimes produced by certain poisonous foods or the distress which is produced by medicines, such as quinine, antipyrine, etc.

In nearly all the reflex eruptions proceeding from alimentary disturbances there will be such generalization of the erythema as to permit avoidance of error. Few, if any, of these troubles commence with the chill which often marks the onset of erysipelas. The appearance of the specific eruption is always distinctive, even pathognomonic. The irregular and advancing outline, the elevation of the involved surface, the peculiar tint, can scarcely be simulated by any other condition. Moreover, if watched for a few hours, vesication, or even formation of large bullæ, may be noticed, along with marked tendency to œdema of loose tissues, like the eyelids, etc.; coupled with this, the ordinary evidences of lymphatic involvement —lymphangitis, enlargement of nodes, etc.—which are never simulated in non-specific diseases.

Prognosis.—The majority of instances of idiopathic erysipelas run a certain limited course, although the eruption may spread to almost any distance from the body. When the disease attacks surgical cases, and especially when it involves wound-areas, the prognosis is not so good.

When, too, the disease assumes an *epidemic* type, and involves indiscriminately cases of all kinds, it will be found to have a *virulence* that may make it a most serious affair. In proportion to the extent to which it assumes the phlegmonous type it will be found locally, if not generally, destructive. The ordinary case of facial erysipelas will get well with almost any treatment or perhaps with little or none. Nevertheless, unexpectedly, meningitis may develop, and even a mild case is to be treated with care and caution, as though one feared disaster.

TREATMENT.—Danger comes from two sources—namely, from *septic intoxication* and *local phlegmons* or gangrenous destruction. Each is, therefore, to be combated so far as possible. Treatment, first of all, should consist of isolation—this rather for the benefit of others than for that of the patient himself.

Especially from all other surgical and puerperal cases should the patient with erysipelas be completely isolated. So far as possible, he should be cared for by those who do not have to do with other surgical cases. Scrupulous care and attention should be given that no contagion may be conveyed from hands, clothing, instruments, dressings, or by any other means. All well-regulated large hospitals are provided with separate wards for reception of such cases, and in many of them the professional attendants as well as the medical men are kept entirely distinct. If one must treat these and other cases as well, he should see the non-specific cases first, and then proceed to the erysipelas patients; after which he should most carefully disinfect his hands and everything that may have come in contact with them.

Rather in opposition to views held a number of years ago, it must be stated that there is *no specific internal treatment* for this disease. The tincture of iron, for example, which was long vaunted as such, has proved utterly unsatisfactory, and is of benefit only as a supporting measure in a limited class of cases. In general it finds but little field of usefulness in this or in any acute surgical disease. *Constitutional* measures should be employed—first, for the purpose of maintaining *free excretion* by bowels and kidneys; second, for the purpose of *supporting* and maintaining strength; thirdly, for tonic and, more important still, lively *stimulant* measures to certain thoroughly prostrated and debilitated patients; and, fourth, for the purpose, so far as may be, of *combating intestinal sepsis or intoxication* from any other source. The robust patients with this disease need no particular tonic, but these are the patients whom it less often attacks. The aged, the enfeebled, the dissipated, the prostrated individuals, and the confirmed alcoholics are those who need vigorous stimulation, partly by alcohol and quinine, partly by strychnia, preferably given hypodermically, and by the other diffusible stimulants by which perhaps alone they may be kept alive. Pilocarpine, given subcutaneously and pushed to the physiological limit, has been highly praised by some. If, along with prostration, there occur restlessness and delirium, then anodynes and hypnotics are most serviceable, and should be administered to meet the indication—morphia hypodermically and any of the agents which produce sleep are now most serviceable. Finally, if there be any drug which can be administered in doses sufficient to saturate the system with an antiseptic which shall at the same time not prove fatal because of toxicity, this is the ideal medicament for constitutional use. Such a drug is not yet known, but it will be well in many of these cases to give some near approach to it

internally, as by administering corrosive sublimate, salol, naphthaline, or something else of this general character in doses as large as can be comfortably tolerated.

When patients become violent—and they sometimes do in the delirium of this disease—it is not only legitimate, but absolutely necessary, to resort to *mechanical restraint*—a strait-jacket, a restraining sheet, a camisole, etc.

Nourishment must also be kept up by the administration of the easily assimilable and, if necessary, of predigested foods in sufficient quantities.

Locally, the number of remedies that have been resorted to in time past is legion. In a very mild case of spontaneous erysipelas—*i. e.* where no infection can be traced—it will sometimes be enough to put on a simple soothing application, like the lead-and-opium wash of our forefathers. It often gives relief to a patient to have the part protected from air-contact, which may be done by some soothing ointment or by dusting the part with some powder, such as oleates of bismuth subnitrate, zinc oxide, etc., these being rubbed up with powdered starch if necessary. Again, it gives relief to protect by a film of rubber tissue or of oiled silk.

Even before the distinctively bacterial origin of the disease was generally accepted it had been suggested to use *antiseptic applications*, either in watery solution or combined with oil or some unguent; and to-day, now that the infectious character of the disease is so completely established, this remains the ideal method of local treatment, the difficulty being only to find that which shall be efficacious as an antiseptic, yet not injurious in other ways. Compresses wrung out of solutions of various antiseptics are often serviceable. Of all the numerous applications which I have ever tried, however, I have found nothing which has given the universal satisfaction afforded by the following prescription or something equivalent to it: Resorcin (or naphthaline), 5; ichthyol, 5; mercurial ointment, 40; lanolin, 50. The proportions of these ingredients may be varied, and I often increase the amount of ichthyol, especially when the skin to which it is to be applied is not too tender. The affected parts are anointed with this, and then covered with oiled silk or some impermeable material, simply to prevent its absorption by the dressings; the parts are then enveloped in a light dressing and bandaged. Whenever I have to deal with local evidences of septic infection, I use an ointment essentially the same as this, and have learned to count on it with more reliance than anything that I have ever resorted to. As the disease becomes mitigated the ointment can, if desirable, be reduced with simple lard, and may be discontinued when local signs have disappeared.

Treatment of *threatening phlegmon*, or that which is from the outset phlegmonous erysipelas, must be much more radical, and consists primarily of free incision down to the depth of the deepest tissues involved. For instance, in treating dissecting and other septic wounds of the fingers, this means incision down to the tendon-sheaths, often down to the bone itself. Unpleasant as this may be, possibly even crippling, it is only by such radical measures, early put into effect, that still worse disaster may be avoided.

If, for instance, the finger which is involved in a dissecting wound and is exquisitely tender and painful, with increasing general septic symptoms, be thus early

incised, it may be saved to usefulness. If incision be delayed, there will in all probability be sloughing and gangrene of tendons, stiffening of the finger, perhaps extensive phlegmonous processes extending up the arm, axillary abscesses, and possibly even loss of life. So, too, all wounds which show evidence of infection must be freely opened, perhaps further incised, sloughs cut away, foul tissue washed, if necessary scraped away, and at every point between the wound and the centres where phlegmon threatens free incision should be made, not necessarily with the view of avoiding local infection, but of at least avoiding gangrenous destruction by inflammatory distension. When these measures are promptly adopted, limbs and often life itself can be saved which would otherwise be inevitably lost. The incisions may be regulated by anatomical considerations, nothing yielding in importance to their necessity save location of large vessels and nerve-trunks, while for the purpose of doing the work thoroughly it is usually advisable to give a general anæsthetic.

THE RELATIONS OF ERYSIPELAS TO CELLULITIS, ETC.

Were it possible, I would like here to make an abrupt distinction between that which has been known in time past as **cellulitis** and the erysipelas already described. Neither clinically, however, nor bacteriologically can such distinctions be maintained, and I hold it futile to endeavor to continue them. *There can be no such disease as erysipelas, cellulitis, nor anything similar which is not distinctly an infection;* and if there exist any differences between them, they obtain rather in the port of entry or path of infection, or the character of the same—*i. e.* whether streptococcus or staphylococcus. In superficial tissues—*e. g.* palm of the hand—or in the deeper parts of the body—*e. g.* in the pelvic cellular tissue—infections are equally likely to occur. These go on always to the point of copious exudation, and almost always to the point of suppuration. When this is superficial, it is nearly invariably recognized and the pus evacuated. In the pelvis, however, it often goes so long unrecognized that collections of pus become encapsulated, and finally altered, by processes already alluded to, which consume a considerable length of time.

Pus, when evacuated from such sources, proves sometimes a pure culture of a distinct organism, at other times a mixed infection. Whether this infection shall assume a fulminating type with rapid and disastrous production of abscess, or whether the whole course of the disease shall be slower, may depend less on location than on individual characteristics and resistance, as well as on the varying virulence of the infecting organisms. But I think it high time that all the older distinctions be dropped, and that all these forms of disease be regarded as infections varying but little one from another—all to be treated, so far as possible, on the same general principles, with the invariable rule, already laid down, that pus left alone and unattacked will do more harm than will the surgeon's instruments if judiciously used. It is on this principle that even such formidable procedures as hysterectomy and cleaning out the female pelvic organs is now a recognized and most valuable measure in cases of pelvic abscess from pelvic cellulitis.

ERYSIPELOID.

This, by some writers, is described under a separate heading, and is a term applied to a wandering erythema met with mostly upon the hands of those who handle dead animal tissues, such as butchers, tanners, oyster-openers, etc. It is certainly due to some infectious substance, its exact character not yet determined. There is infiltration of the skin with a reddish discoloration, itching, local discomfort, etc., but without fever, the local lesion spreading slowly and seldom above the wrists. In its course it is obstinate and resistant to treatment. Rosenbach and Cordua claim to have produced this disease by inoculation of a coccus growing much like cladothrix dichotoma.

Such a condition as this would best be treated by the resorcin-ichthyol ointment whose formula has already been given.

CHAPTER VIII.

SURGICAL DISEASES COMMON TO MAN AND THE DOMESTIC ANIMALS.

By Roswell Park, M. D.

Tetanus.—Synonyms: Trismus, Lockjaw.

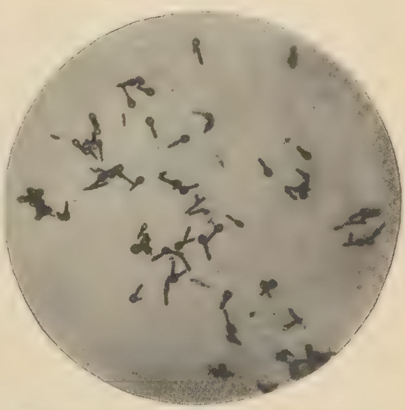
Tetanus is an *acute infectious disease*, at present of infrequent occurrence, *invariably of microbic origin, characterized by more or less tonic muscle-spasm with clonic exacerbations*, which, for the most part, occurs first in the muscles of the jaw and neck, involving progressively, in fatal cases, nearly the entire musculature of the body. Certain *races* of people seem predisposed, and in certain climates and geographical areas the disease is exceedingly prevalent. Negroes, Hindoos, and many of the South Sea Islanders show a peculiar racial predisposition, and, in a general way, inhabitants of warm countries are less resistant. This is shown partly by the fact that in various European wars the Italians and French have suffered more than the soldiers of more northern climes. Tetanus is by no means confined to adult life, since infants are far from exempt, and in the *tropics* the *trismus of the new-born* is the cause of a high mortality-rate. In Jamaica one-fourth of the new-born negroes succumb within eight days after birth, and in various other hot countries the proportion is at times equally great. One plantation-owner states that fully three-fourths of the colored children born upon his plantation succumbed to the disease. The peculiar reason for this infection will appear a little later when speaking of *tetanus neonatorum*. Men seem more commonly affected than women, probably because of their occupations, by which they are more exposed. Military surgeons have had to contend with the disease in its most frightful form, and it has been noted that soldiers when worn out by fatigue or suffering from the disaster of defeat seemed more liable to the disease. In 1813 the English soldiers in Spain suffered from tetanus in the proportion of 1 case to 80 wounded men. In the East Indies, in 1782, this proportion was doubled. Quick variations of heat and cold, such as warm days and cold nights, coupled with the other exposures incidental to military life, seem to exert a great effect. Curiously enough, the wounded in many campaigns who have been cared for in churches have suffered more from the disease than those cared for in any other way. Tetanus, however, is by no means necessarily confined to any one clime or race, but may be met with anywhere, at any time, providing only that infection have occurred. A celebrated Belgian surgeon was unfortunate enough to lose by tetanus 10 cases of

major operations before he determined that the source of the infection pertained to his hæmostatic forceps. So soon as these were thoroughly sterilized by heat he had no further undesirable complications. If the disease can be so conveyed by the instruments of a careful surgeon, how much more so by the dirty scissors of a careless midwife, etc.!

It is true, also, that the popular notions of the laity concerning the liability to tetanus after certain forms of injury is not ill-founded. Small ragged wounds of the hands and feet are those which ordinarily receive little or no attention, and are among those most likely to be followed by this disease. The *toy pistol*, which, a few years ago, was such a prevalent and widely-sold children's toy, was guilty of many a small laceration of the hand, due to careless handling and the peculiar injury produced by the explosion of a small charge of fulminating powder in a paper or other cap. It was not the character of the laceration or injury thereby produced, but the fact that such injuries occurred in the dirty hands of dirty children, which were most likely to become infected, that has caused the so-called *toy-pistol tetanus* to be erected almost into the dignity of a special form of this disease. During the month of July of 1881, in Chicago alone, there were over 60 deaths from tetanus among children who had been injured in this way by these notorious little toys. This led to their sale being suppressed by law.

ETIOLOGY.—In time past two theories have had strong advocates, one being that which would account for the disease by irritation of nerves—a nervous theory; while the second, the humoral, would explain the disease by alterations in the blood. Each has had its most ardent defenders, but both have now completely yielded to the investigations of a few observers, among whom Kitasato and Nicolaier are the most prominent. These ardent workers have been able to clearly establish the *parasitic* nature of this disease and to isolate and investigate the organisms by which it is produced. This was in 1885.

FIG. 33.



Tetanus bacilli, showing spore-formation (Kitasato).

The bacillus of tetanus is a somewhat slender rod-shaped organism, with a peculiar tendency to spore-formation at one end, which gives it a drumstick appearance. It is essentially an anaërobic organism, and can never be cultivated in contact with the air. In laboratory experiments it is grown in the depths of a solid culture-medium or else in fluids and on surfaces in an atmosphere of hydrogen gas. It is one of the apparent contradictions of bacteriology that this organism, which can only be grown as an anaërobe, nevertheless abounds in earth, particularly the rich black loam which best supports luxuriant vegetable life, and that it practically inhabits the upper layers of the soil, which accounts for the fact that so many contaminations and infections have occurred from stepping upon planks or boards with nails projecting, or from introduction of splinters, or from lacerations of the hands and feet which are so often followed by contact with such materials. There is nothing about a rusty-nail wound which, by itself, predisposes to tetanus, but the rusty nail upon which the barefooted boy steps is either itself infected or leaves a rent or wound which the boy may infect within the next few moments, and which is not likely to receive the careful attention which it ought to have. Verneuil has of late laid stress upon the fact that in localities where horses are kept tetanus is more prevalent, and that the infectious organism abounds in and upon stable-floors, about barn-yards, and wherever the excretions of a horse may be found. Bacteriologists are all aware

that in the intestine of herbivorous animals the bacilli (anaërobic) of tetanus and malignant œdema are often found. Verneuil has further shown that almost the only instances of tetanus which occur on shipboard are upon those ships which are used for transportation of horses and cattle. His statements are at least interesting, if not absolutely well founded. At all events, tetanus is certainly of telluric origin.

The tetanus bacillus manifests other peculiar properties, for some of which it is most difficult to account. Upon susceptible animals it is violently infectious, but is very rarely found at any distance from the tissues in which it has first lodged, and it has never been satisfactorily demonstrated far away from them. In laboratory investigations the period of incubation is seldom longer than forty-eight hours. Another peculiarity of the organism is that it generates certain poisons of most active properties which may be separated from pure cultures, by whose injection the peculiar spasms of the disease itself may be reproduced. These have been isolated, especially by Brieger, who has given to them the names of *tetanin*, *tetanotoxin*, *spasmotoxin*, etc. They will be found alluded to in the Appendix to Chapter VI.

Tetanus has been spoken of as *idiopathic* and *traumatic*. Here, again, the term "idiopathic" is simply a confession of ignorance, and in the light of our positive knowledge concerning the infectious character of the disease should be abandoned. It simply means that the path of infection has not been discovered. Tetanus, then, is *essentially a traumatic disease*, since it has not been established that infection can occur upon unbroken skin or mucous membrane.

Tetanus neo-natorum, or *tetanus of the new-born*, a condition already alluded to, is a remarkably fatal affection, very prevalent among the negro race, especially in hot climates. It in no wise differs from traumatic tetanus, but is such in effect, since the infection in these instances always follows the *division of the umbilical cord*, which is usually effected by dirty scissors in the hands of a dirty midwife, while the thread with which the cord is tied is itself a possible source of infection, as well as the rags which are used to cover the umbilicus in the first dressing. It is virtually always fatal, because of the weakness and lack of resistance of these little patients. It occurs usually within a week after birth, if at all. **Tetanus cephalicus**, called also *tetanus hydrophobicus* and *head-tetanus*, is only a peculiar manifestation of this same affection, confined for the most part to the head and usually following injuries to this region. The muscle-spasms are, for the most part, confined to the facial, pharyngeal, and cervical muscles, sometimes extending to the abdominal. These manifestations may be in some measure reproduced in animals by inoculating them on the head rather than upon the extremities. It is the least fatal form of the disease.

SYMPTOMS.—There is always a *period of incubation*, usually three or four days, occasionally a week in length, and rarely considerably longer.

In my own experience I have seen the symptoms retarded until after complete and absolute healing of the wound to which they were apparently due; and in one instance, to my positive knowledge, there must have been an interval of six, possibly eight, weeks between the visible opportunity for infection and the first manifestations of the disease, which proved fatal.

It is generally held that the longer the period of incubation the more hopeful the prognosis. While for the most part the disease assumes a most acute type, a chronic tetanus is described and occasionally met with. The *first warning* of the disease usually comes as more or less *stiffness* of the *cervical* and maxillary *muscles*, which is likely to be spoken of by

the patient as a "sore throat," because of the consequent difficulty in deglutition. A complaint to this effect should be always regarded as a warning, especially if, on inspection, no visible reason for it can be detected in the pharynx. This complaint is usually made in the morning after an ordinary night's rest. This muscle-stiffness will be followed by increasing *tonic spasm* in the *muscles of the jaw*, making it difficult to open the mouth, while the head and neck gradually become stiffened and fixed by spasm of the cervical muscles. These muscles may now be felt more or less rigidly contracted, as if by voluntary effort, and the condition, which is at first not painful, becomes after some hours a source of discomfort, perhaps of actual pain, to the patient. If, now, the disease pursue the usual course, the other muscles of the body become gradually affected, usually in the order of their proximity, but not necessarily so. The *abdominal muscles* are *firm* and board-like, and the dorsal muscles more or less contracted, sometimes to an extent which causes arching of the spine. Should the original wound or port of entry for infectious germs have been in the hand or foot, the muscles of this limb become contracted, more or less rigidly, holding it in a position which is not easily changed, even by efforts of the attendant. Sensation is also often more or less perverted. In this condition of tonic rigidity the muscles remain, to relax usually only with death.

FIG. 34.

Characteristic tetanic spasm in a rabbit twenty-six hours after inoculation with pure culture of tetanus bacilli (Tizzoni and Cattani).

The most *characteristic features* of the disease, however, are the peculiar *clonic exacerbations*, which *convert spastic rigidity* into *violent and convulsive muscle-activity*, so that the limbs, and even the frame, of the patient are more or less contorted, the muscle-exertion being sometimes most painful to witness. Peculiar effects are thus produced: the mouth is peculiarly puckered, and its corners drawn upward and backward by the risorius muscles, giving to the face that peculiar expression known as the "sardonic grin." When the abdominal and flexor muscles of the thighs are especially involved, the body is more or less curved forward, and this is known as *emprosthotonos*. When the muscles of the back especially are involved, with the extensor muscles of the thighs, we have *opisthotonos*, while, when the body is bent to one side or to the other, it is spoken of as *pleurosthotonos*. It is said that opisthotonic convulsions occur to such extent in rare instances that the heels may even touch the head. At all events, the patient's body is frequently raised from the bed, so that he rests upon the head and feet.

Another most characteristic feature of the disease is the peculiar

reflex irritability or *hyperæsthesia* by which these convulsive attacks apparently are produced. Into this one falls more or less rapidly within the first day after the inception of the disease; and to such a height may it be augmented that the slightest movement in the room, jarring of the bed, or displacement of clothing, even noise or a flash of light, may immediately bring on a convulsion. Rupture of muscles has been reported during some of these violent convulsions.

During the course of this disease the jaws are so fixed that patients speak with extreme difficulty and the tongue cannot be protruded. The mind is clear until the end. The pain is rather the acute soreness due to intense muscle-strain. There is spasm of sphincters by which urine and fæces are often retained. There is nothing characteristic about the temperature, which is seldom much augmented. Attempts to swallow give pain, and are resisted specially because of the renewed muscle-spasm which is likely to follow the irritation inseparable from the act itself. As the result of spasm of the glottis peculiar respiratory sounds may be noted.

Until the last only the voluntary muscles are involved. Finally, however, come spasms of the accessory respiratory muscles, and, lastly, of the diaphragm; and death is usually produced by involvement of these muscles analogous to that of the others. *Death results*, then, usually from *apnœa* or *suffocation*. During the last hour or two perspiration may be copious and temperature may rise.

Chronic tetanus is characterized throughout by a milder and much more prolonged series of symptoms. The period of incubation is much longer, and, while the general programme of the acute form is adhered to, it is of less severe degree and is spread over a longer time; in fact, cases covering two months or more are reported. In chronic tetanus the prognosis is much more hopeful than in the acute form.

So far, nothing has been said about the appearance of the wound. This is but slightly, if at all, affected. In some cases it will be found to have completely healed before the onset of the disease. If suppurating or open, its evidences of repair will be found unsatisfactory and some indications of septic infection may be noted. Pricking or needle sensations may be subjective phenomena.

Prognosis.—Prognosis is almost invariably bad. No case of acute tetanus under my own observation has ever yet recovered. Still, occasionally recovery does ensue. Whether this be due to a peculiarity of the patient or to the medication is, perhaps, still doubtful. If patients live more than five or six days, the prognosis is thereby certainly bettered.

Post-mortem Appearances.—These are rarely distinctive. In most instances there are evidences at least of hyperæmia, if not of more active changes, in the upper portions of the cord. Much less often slight changes have been noted in the brain, consisting, in some measure, of disintegration and softening. Evidences of ascending neuritis in the nerve-trunks leading to the injured area have been claimed in some instances. As a matter of fact, however, few, if any, distinctive post-mortem changes can be described as due to this disease.

Diagnosis.—This must be made as between *strychnia-poisoning*, *hysteria*, *hydrophobia*, *tetany*, and, in the very beginning, from pharyngitis, tonsillitis, etc. When the disease is fully developed it is not likely to be mistaken for anything else.

In *strychnia-poisoning* the muscles of the jaw are the last to be affected, in tetanus the first. There is, too, in strychnia-poisoning hyperæsthesia of the retina, and objects are often seen green. There is no foaming at the mouth in tetanus, and the symptoms of strychnia-poisoning which would probably lead to the question of diagnosis would extend over a comparatively brief period of time, after which there will be either amelioration or death.

In *hydrophobia* the whole picture is of mental excitement and distress, and in genuine hydrophobia there is a definite history of particular accident, which will be always suggestive. The hydrophobic muscle-spasms are, for the most part, limited to muscles of respiration and deglutition. In tetanus the patient instinctively remains as quiet as possible; in hydrophobia he is restless, and perhaps requires mechanical restraint. In tetanus the mind is clear to the last; hydrophobia is characterized by mania.

Tetanus may be simulated by *hysteria* in patients of a certain class, but in this event the phenomena will be so uncertain, so contradictory, and the evidences of real organic disease so essentially lacking, that it is not likely that mistake can occur.

TREATMENT.—If any case can be imagined in which efficient treatment is most urgently demanded, it is one of tetanus. In scarcely any disease, however, is treatment so unsatisfactory. In the rare instances in which patients recover one questions whether it is not due to individual resistance rather than to medication. Treatment may be subdivided into *local*, *constitutional*, and *specific*. If there be still an *open suppurating or discharging wound*, it is well to anæsthetize the patient and to thoroughly cleanse this out, basing this advice in some measure upon general principles—largely upon the fact, already stated, that only the immediate surroundings of such a wound are found infected by the bacilli themselves. Consequently, thorough *scraping*, *excising*, and *cauterization*, either with powerful caustics or the actual cautery, are indicated. If it be in a finger or toe, amputation may be the simplest method of eradicating the local lesion.

Nerve-elongation (stretching) has also been suggested, and for some years was practised in connection with these operations, the nerve-trunk supplying the affected part being exposed and vigorously stretched. This was done at a time when a specific cause was not yet determined, and may now be abandoned in the light of more recent knowledge, without detriment to patients. The use of hydrogen dioxide or caustic pyrozone about all local lesions would seem to be indicated, because the germs only grow in those tissues which are starved of oxygen, and because in the presence of excess of free oxygen they are killed.

Constitutional treatment may be divided into *nutrition* and *medication*. The tendency too often in these cases is to be careless or indefinite with regard to the excretions and the nutrition of the patient. If, for instance, each attempt at catheterization throw him into convulsions, the bladder may become over-distended, and even may possibly burst. So, too, there is apprehension usually with regard to fecal evacuations. At the same time, these patients are allowed to almost starve because of the difficulty of feeding them. My advice first, then, is to resort to chloroform at least often enough to permit the introduction of a stomach-tube—through the nostrils, if necessary—by which nutrition may be introduced into the stomach without causing the violent convulsions that would certainly occur without an anæsthetic. At the same time, the catheter may be used if necessary.

Along with nourishment may also be given such cathartics or purgatives as may be indicated, or at the same time a more or less copious high enema may be introduced for the purpose of thoroughly unloading the bowels. If one may be

permitted the Hibernicism, these patients, as often cared for, would starve to death if they did not die of suffocation; and nutrition is certainly most important.

In the way of *active medication* there is no agent so efficacious for controlling the tetanic spasms as *chloroform*, which may be administered occasionally, or more or less continuously, according to the wishes of the attendant. By its use the severest spasms at least can be kept in abeyance, and the horrible character of the disease somewhat mitigated. Of the other medicaments used, most of them are of the nature of nerve-sedatives, such as *chloral*, the *bromides*, *Calabar bean*, *cannabis indica*, *opium*, etc. By continuous but mild dosage with Calabar bean (*eserine, hypodermically*) the severest manifestations can often be, in a measure, controlled, providing only it be given in small doses. Poncet suggests to give 1 to 1½ grains of extract by the mouth every four hours, or to inject 15 to 20 drops of a 1 per cent. solution of the same hypodermically. Chloral has been used by the mouth, the rectum, and injected into the veins. While more or less reliable in relaxing the convulsions, it is depressing in other ways, and apparently not finally successful. Opiates have been given in enormous doses, and are called for especially when there is severe pain. The bromides, if used, must be given in large and increasing doses.

Curare, on account of its peculiar effect in paralyzing voluntary muscles, has been suggested and frequently resorted to. On account of the difficulty of getting a reliable specimen, it is not always at hand, and even then one must experiment with it in order to learn the exact dose of a given specimen which the patient can safely tolerate. Hot-air baths or diaphoretics, by which copious perspiration may be induced, have yielded good results in certain cases. In fact, they were in general use several centuries ago. Cold applications down the spine, or spraying the spinal region with ether or other volatile substances by which heat is abstracted have also had their advocates, the intention being to produce spinal anæmia, so far as possible, as the reflex result of external cold. But to do this means to disturb the patient, and the practice has not been generally followed.

Specific treatment means in these instances taking advantage of the now well-known properties which the *blood-serum of an animal artificially immunized* against the disease possesses. This is in accordance with recent experimental labors with a number of different diseases, of which tetanus is one. It is, in effect, similar to the serum-therapy of diphtheria so recently introduced.

The animal used is the horse, which is immunized by injecting at first small, then increasing, doses of active cultures of tetanus bacilli, sufficient to affect the animal, but insufficient to kill. In this way an increasing degree of immunity is produced, until a point is reached where the animal seems absolutely insusceptible to the disease, even in its most virulent form. Blood is now drawn from this animal, its serum separated, and this used for subcutaneous injection in doses usually determined by its ascertained strength and active properties.

This is the method elaborated by Tizzoni and Cattani, while the material made from such serum according to their method is known as the *tetanus antitoxine*. It is prepared by precipitation by absolute alcohol and solution again in glycerin. There are now on record a number of instances where men suffering unmistakably from the disease recovered after use of this antitoxine. Although the number is yet relatively

small, and although some doubt has been attached to some of these case reports, it would seem that the majority of them at least are authenticated, and that a remedy has at last been supplied, more hopeful and full of promise than anything heretofore offered to the profession.

Tetany.

Under the heading of Diagnosis of Tetanus it was stated that it is necessary sometimes to differentiate tetanus from tetany. This latter condition is one which seldom pertains to surgical cases, and the subject is introduced here rather for the avoidance of error than because of desire to complicate this already abstruse subject. From the great resemblance in names the student may infer that there is resemblance between the diseases. This is not the case. **Tetany** *is a non-specific disease—i. e. a neurosis—characterized especially by tonic spasms,* particularly of the extremities, and by increase of mechanical and electrical excitability of peripheral nerves. However, it follows certain operations, notably thyroidectomy, and, although in a measure interchangeable with another distinct neurosis—namely, *myxœdema*—it may nevertheless occasionally cause alarm because of its convulsive manifestations.

It occurs sometimes spontaneously in pregnant and nursing women, and is met with in children after exposure to cold or after such intestinal lesions as may be produced by typhoid or by parasites. It occurs also in endemic or epidemic form, and has been described under various names—as *tetanella*, *idiopathic muscular spasm*, *carpo-pedal cramp*, *etc.*—the muscle-spasms occurring in reasonably regular order or rhythm, while patients do not lose consciousness. It is pathognomonic of the disease that the muscle-spasms of a part may be produced by compression of its great vascular or nerve-trunks. This was established by Trousseau, and is known as *Trousseau's sign.* Another peculiarity was first described by *Chvostek*, in that a slight tap upon the side of the face over the point of emergence of the facial nerve from the parotid suffices usually to call forth a sudden spasm of that side of the face.

The *symptoms of post-operative tetany* may supervene almost immediately after operation or may be delayed so long as ten days. The muscles of the face are first affected; then those of the upper extremity. The hands are usually flexed to the ulnar side with fingers bent at the metacarpo-phalangeal joints—that is, straight and stiff, the thumbs bent into the palms. Sometimes the fist is doubled up with the thumb between the first and second fingers. The muscles are in a condition of moderate tonic rigidity which is always difficult to overcome. During the muscle-spasms there is more or less pain, often with elevation of temperature. These spasms may last even fifteen minutes, but do not occur with such frequency as those of true tetanus. Nevertheless, in the severest cases of tetany is seen a facial spasm simulating the sardonic grin of true tetanus. Post-operative tetany is always serious, often fatal. It may be imitated by removing the thyroids of kittens or young cats. Usually within two or three days the symptoms of the disease are present and characteristic. Treatment seems to be unavailing, at least by ordinary drug-medication. In a case of tetany, either idiopathic or post-operative, the most hopeful medication would be the administration of thyroid extracts, either fresh or prepared by desiccation. These in some instances have given great relief.

In several instances where the disease has followed extirpation of goitre, thyroidal transplantation has been tried—*i. e.* the transplantation of a thyroid from another animal—either into the abdominal cavity of the patient or, better still, into some convenient cavity made for its reception; for instance, behind the mammary gland, in the fleshy part of the thigh, etc. It has been pretty clearly established experimentally that there is always risk of tetany, myxœdema, or some other expression of auto-intoxication when more than four-fifths of the thyroid body is removed.

HYDROPHOBIA.

Hydrophobia is *an acute specific or infectious disease*, so far as known *never originating in man, but transmitted to him, usually through the bite* or by inoculation from the saliva *of a rabid animal*—in this country usually the dog, although the wolf, the cat, the skunk, and even certain of the domestic poultry, are capable of conveying the disease. It can also be inoculated in other animals, like rabbits. The *virus* is ordinarily conveyed in the *saliva* of the rabid animal. This may be wiped off as the teeth of the animal pass through the clothing of the injured individual; consequently, infection does not certainly follow such bites. But those upon exposed portions of the body, where animals generally bite, are almost invariably followed by infection. Hydrophobia is frequently spoken of as **rabies**, sometimes as **lyssa**. While rare in this country, it is by no means rare in Central Europe, especially perhaps in Russia, where bites from infuriated wolves are relatively common. In the United States infection comes almost invariably from the rabid dog, in whom this disease presents two types.

The so-called *furious form* is that which is marked by frenzy and canine madness, the objective symptoms being more pronounced and alarming, though not less dangerous, than the other variety. After the period of incubation, which varies considerably, these animals show depression and uneasiness, and even thus early their saliva is infectious. Their sense of hunger becomes perverted; they exhibit unusual tastes, secrete saliva abundantly, which becomes very tenacious and even frothy, exhibit a dry and œdematous condition of the faucial mucous membranes; the character of the bark is altered, while they are usually infuriated at the sight of other dogs. In this stage there is usually insensibility to pain. Finally, come more or less paralysis of deglutition, quickened respiration, dilated pupils, and frenzy and madness of manner, by which they attack indiscriminately men and other animals. To this stage of furious excitation succeeds one of paralysis, and, finally, death follows from exhaustion. These manifestations usually last about a week.

Dumb hydrophobia is the more common form. Here paralysis appears much earlier and involves especially the lower jaw; the tongue falls out of the mouth; and the posterior extremities are quickly paralyzed. This form is much more quickly fatal than the other.

Hydrophobia in man is rare in this country, yet is occasionally met with. Its etiology is as yet completely obscure. That a *contagium vivum* is present is positive, but its nature is absolutely unknown.

Pasteur, who has done so much work in protecting from and treating this disease, holds to the view that the peculiar virus is made up of two distinct substances —the one an organized living virus capable of multiplication, particularly in the nervous system; the other inorganic, and capable, when present in sufficient proportion, of arresting the development and growth of the other. Whether this *contagium vivum* is bacterial, protozoal, or something else is not known. Babes claims to have cultivated on blood-serum an organism extracted from the brain of

hydrophobic rabbits, which, upon inoculation, occasionally reproduces the disease. This, however, is far from being sufficient evidence to establish the bacterial nature of the disease. Fol has found small granules in large masses within the nerve-structures, each granule taking a deep violet stain, while from cultures which he claimed to have made he could produce a modified hydrophobia in animals. While everything, then, points to the organized character of this virus, we are not in position to speak with any definiteness concerning its exact nature.

Symptoms.—The *period of incubation* in man is very variable, ten weeks being perhaps the average. It is shorter in children, as also when the bites are numerous. It is even stated that it may be so long as a year or more, during which time the poison seems to lie latent. When the active symptoms supervene there are, locally, discomfort about the wound, itching, heat, and peculiar unpleasant sensations. It is said also that, in some cases at least, vesicles make their appearance in the neighborhood of the original lesion. *As in animals, so in man*, the disease may assume either the *furious* or the *paralytic* type. These cases are nearly all marked by mental depression and apathy, with complete loss of courage. The earlier symptoms are connected perhaps with the respiration, which is infrequent, while inspiration is halting and speech is interfered with. The facial appearance is often changed to one of anxiety, even despair. The muscles of deglutition are next involved in a combination of spasm and paralysis, and the act of swallowing is interfered with, sometimes made almost impossible. Although patients can swallow their own saliva, they find it most difficult to swallow any foreign substances, such as water, etc. This is *not due to the fear of water*, as the term "hydrophobia" would imply—this being an absolute misnomer—but is due to reflex spasm excited by the attempt. It is accompanied by more or less sense of suffocation and palpitation of the heart. Indeed, a paroxysm of this kind may be precipitated by the attempt to swallow, so that the patient instinctively refuses water or any other fluid. *Reflex excitability* is also very great, and a breath of air or a trifling disturbance may precipitate a paroxysm, almost as in extreme cases of tetanus. As the case progresses the saliva becomes more tenacious and viscid, faucial irritation more marked, and the attempts to expel the secretion, along with the disturbed respiratory efforts, have given rise to the foolish lay notion that these patients bark like dogs. The paroxysms, as the case progresses, become more marked, the patient more restless, until, later, furious mania or muttering delirium is present, to be followed by prostration and paralytic phenomena, muscle-tremor, etc., and death.

The *paralytic form in man*, as in dogs, is marked by the much earlier paretic phenomena, anæsthesia, and, finally, respiratory paralysis, which terminates the case. Curtis and others have insisted that the hydrophobic paroxysms are not convulsions in the ordinary sense of the term, but are due to temporary inhibitions of the most important respiratory and cardiac centres as the result of peripheral impressions. He would liken them to the shock of a shower-bath.

Post-mortem Changes.—Post-mortem changes are indistinct and only suggestive. For the most part they are found within the nervous centres—most prominently in the medulla, then in the hemispheres, and then in the spinal cord. There is hyperæmia, with minute ecchymoses, with infiltration of the adventitia of the vessels and perivascular extravasation. The changes met with in the other viscera bear no constant relation to symptoms. Nevertheless, Gowers holds that because of the

location of the lesions and their intensity in the neighborhood of certain nerve-nuclei we have here a distinguishing anatomical character of the disease.

Diagnosis.—As between hydrophobia and tetanus, diagnosis is not difficult, as already described. In certain hysterical individuals nervous paroxysms, largely due to fright, may be precipitated by dog-bites and other incidents or accidents. In these cases there is rarely, if ever, such a period of incubation, and in a true hysterical case there will be no such mimicry, of this awful disease. A condition known as *lyssophobia* (fear of hydrophobia) has been described. It is seen for the most part in hysterical subjects. It is said to have even been fatal, but this must have been from other complications.

Treatment.—There is no authenticated case on record of recovery after medication by drugs. It is probable that recovery has never followed anything save the modern inoculation-treatment.

Reliable statistics are wanting as to the time during which it is possible to use caustics in a wound made by the rabid animal's teeth, and thereby to avert inoculation. When it is known that a given injury has been produced by the bite of a rabid dog, local bleeding and suction of the wound, followed by complete cauterization or even extirpation of the injured area, would be advisable. It will be necessary for the medical man occasionally to combat that most foolish of all popular superstitions, that destruction of the animal will save the patient from active disease after an injury. This notion is quite prevalent. On the contrary, it would be much better to keep the animal safely restrained, in order that he may be watched, because if he develop the disease there will still be time to save the patient by the Pasteur treatment, whereas if he do not develop the disease the patient's fears may be completely set aside.

The essential and only successful treatment for this disease has been elaborated as the result of the labors of that indefatigable French savant, Pasteur, and is among the most glorious triumphs of laboratory research, against which it is so often charged that it is not practical in its results. It is in some respects a curious commentary on the study of infectious disease that we can secure and work with the peculiar virus of hydrophobia, and at the same time be utterly unacquainted with its true character. To this fact is due the modern cure. It is based upon the fact also that the virus obtains not only in the saliva, but in the nervous system of animals suffering from this disease; also to the fact that its effects are intensified and hastened by inoculation directly into the cerebral substance.

Virus obtained from the brain or cord and inoculated into the dura of another animal quickly precipitates the disease. It is, moreover, modified in virulence as it passes through successive animals of certain species—for example, monkeys. Curiously enough, it is increased by passage through rabbits, and the period of incubation thereby shortened. The weakest virus can by proper handling and manipulation in this way be so intensified as to produce disease within seven days after inoculation. Desiccation reduces the virulence, and preparations from the cord of an infected animal may be attenuated to almost any desired extent by drying. By inoculating a dog or a rabbit, for instance, with virus prepared from this weakened source, and daily making injections from stronger and stronger preparations, he is in the course of a couple of weeks rendered practically immune to the disease. Animals thus made immune are trephined, and the virus injected beneath the dura, by which much more certain results are obtained.

Pasteur has, furthermore, shown us how to hasten the result by resorting to what he calls *the intensive method*—by the administration of virus of increasing strength at much shorter intervals. As in the case of vaccination against smallpox, if the vaccine virus be introduced sufficiently quickly after exposure to variola

it may still serve as a protection, so in the case of hydrophobia, if the bitten patient can be treated by these preventive inoculations before the symptoms of the disease manifest themselves, they may be permanently averted. Upon this whole matter protection as against hydrophobia hinges.

The conditions surrounding the laboratory work necessary in connection with this method of treatment are such that it is practicable only in some large institution supported by government or other public means. Nearly all the rabic patients of Europe proceed to the Pasteur Institute in Paris, which is naturally their headquarters. In New York a similar institute is conducted under the care of Dr. Gibier; and my advice to an individual bitten by a suspicious or positively rabid dog would be to place himself under treatment in one of these institutions. Injections are made after the fashion indicated, by the subcutaneous method, about the trunk, and are daily repeated for two or three weeks. The results of this method have been such as to immortalize Pasteur and to effect a revelation in the consideration and treatment of certain infectious diseases. Statistics are fallacious and capable of manipulation. It is, however, positively established that a very large proportion of those who have received this treatment before the onset of specific symptoms have been redeemed from an otherwise certain grave. All honor, then, to the man and to the method which he devised!

Glanders and Farcy.

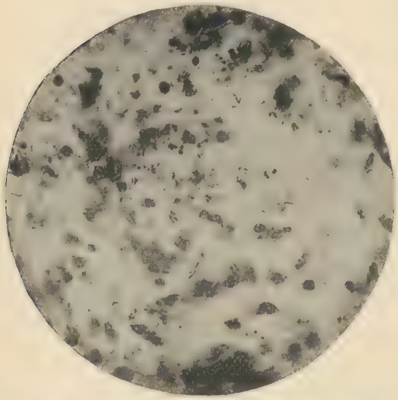
Glanders as it is ordinarily known in man is a *specific infectious disease, transmitted, for the most part, from the horse, characterized by rapid formation of specific granulomata*, particularly in the skin and mucous membranes, *which quickly break down into ulcers*, and by the general toxæmia of any acute infection. In German it is known as *rotz;* in French, as *morve;* while its old Latin name was "malleus" (hence we speak of the *bacillus mallei*). It was also known in former days as *equinia.* In horses the disease has also been known as *farcy*, because of the peculiar subcutaneous nodules which farriers and hostlers almost from time immemorial have called "farcy buds." The disease, while capable of transmission from man to man, is virtually always produced by contagion from some of the domestic animals, most commonly the horse, although sheep and goats are known to occasionally have it, and dogs are quite susceptible, though seldom showing manifestations of it. Cattle are immune against general infection, but occasionally show local ulceration. In menageries it is known that lions and tigers may become affected. Field-mice are extraordinarily susceptible, while house-mice and white mice are quite exempt. The pigeon is the only bird known to be susceptible. Glanders has been met with occasionally among laboratory investigators, and the glanders bacillus is one of the most dangerous organisms with which students can work in the bacteriological laboratory.

Like some of the other infectious diseases, glanders appears to be variable in its manifestations. While infection occurs probably through some superficial abrasion, it is almost certain that it may also occur through the unbroken mucous membrane of the respiratory organs. It is said to be also capable of transmission from mother to fœtus *in utero.* So far as known in man, infection occurs practically invariably through some slight abrasion, either of the skin or the mucous membrane of the nose, the eye, or the mouth. The discharges from the nostrils of affected animals are extremely virulent, and infection comes usually from this source. It is said to have been communicated from one patient to another by eating from the same dish or by drinking from a pail used by a diseased horse.

Glanders is due to the specific bacillus known as the *bacillus mallei.* It is shorter and plumper than the tubercle bacillus, in length about one-third the diameter of a red corpuscle. It is a non-motile organism,

occasionally spore-bearing, not very resistant, belonging to the facultative anaërobic forms, growing best at blood-temperature, taking stains easily, and losing them in the same way. By continuous cultivation its virulence is attenuated or almost lost; consequently, conditions outside of living organisms are unfavorable for its growth. It is conspicuously found in the granulomatous nodules which are characteristic of the disease.

FIG. 35.



Bacillus mallei; section from spleen; bacilli seen between the cells; × 500 (Fränkel and Pfeiffer).

SYMPTOMS.—Glanders is met with almost invariably in workers and hangers-on in stables. The *acute*—the common—form has a *period of incubation* of from three to seven or eight days, after which both local and general symptoms supervene. About the infected region a form of cellulitis appears, assuming often a more or less phlegmonous type, with implication of the adjacent lymphatic nodes and evidences of periphlebitis and perilymphangitis. Over the affected area *vesicles* appear, which become hemorrhagic, and later suppurate. A wound which has healed may reopen. Almost always there are accompanying constitutional disturbances of septic type, occasional chills, pyrexia, etc. It is rather characteristic of glanders to have severe pain in the muscles and extremities, with epistaxis and formation of metastatic tumors and œdematous swellings in various parts of the body. Frequently, later in the disease, comes a somewhat distinctive eruption, papular in character, merging into pustular. Hemorrhagic bullæ are also often seen. Pustulation and œdema of the face change its appearance notoriously. There take place also œdema of the eyelids and *mucopurulent discharge from the conjunctivæ and the nose.* This latter discharge is often even ozænous in character. Upon inspection of the naso- and oro-pharynx a similar condition will be noted. In connection with these local signs more or less general furunculosis will also be observed. Obviously, as these local conditions intensify and multiply septic disturbance will be increased, and the patient dying of acute glanders dies in large measure of septicæmia or intoxication and exhaustion combined.

A chronic form is known, distinguished mainly by slowness or tardiness of lesions, though the local changes are not particularly different in character. There is perhaps more tendency to suppuration and less to lymphatic complications. The nodule which breaks down will leave a foul ulcer, the *discharge* from all these lesions being *extremely infectious.*

Each of these nodules, or *farcy buttons*, is similar in make-up to the local collections of cells which constitute the so-called granulation-tumor or *granuloma*, and in these respects is analogous to tubercle and syphiloma. They are, therefore, expressions of cellular activity as a protection against the inroads of a specific irritant. They break down rather by superficial destruction, and constitute the ulcers above mentioned. They will be met with in all sizes, from the miliary nodule to the tumor of considerable volume. Similar masses will form wherever the lymphatic current carries the bacilli; consequently they may be met with in the muscles and elsewhere.

Diagnosis.—This is not always easy, but may be based in suspicious cases to some extent upon the occupation of the patient. The presence of multiple lymphatic lesions and subcutaneous nodes, especially when breaking down as above described, and accompanied by ozænous discharge from the nose, should at least be most suggestive, and will serve to distinguish between this disease and, for instance, typhoid fever. The chronic type of glanders might be mistaken for syphilis, and here is where the real difficulty of diagnosis will probably obtain. In doubtful cases the crucial tests would be microscopic examination of discharges after staining for bacilli, and the cultivation test.

Prognosis.—A generalized attack of glanders is a matter of gravest import, especially when acute. Scarcely more than 10 or 15 per cent. of such cases recover. In the more chronic manifestations the prognosis is very much better, half of the patients making a final recovery.

Treatment.—All infected animals should be quickly isolated and destroyed, their carcasses being *burned*. If possible, the infected wound or abrasion should be coaxed to bleed freely, and then cauterized with some active caustic. By prompt interference with the first manifestations it may be possible to cut short the disease. This would necessarily be done by *excision*, *cauterization*, *packing*, etc. Bayard Holmes has reported a case in which, during two and a half years of chronic manifestations of this disease, he anæsthetized the patient twenty times for the purpose of opening new foci or scraping out old ones, finally obtaining a permanent cure. There is no specific treatment, but the septic symptoms should be combated as already indicated in the chapter on Septicæmia.

By making a *glycerin extract* from the filtered and evaporated culture of the glanders bacillus it is possible to prepare a toxalbumen analogous to tuberculin, which reacts in a similar way. By it animals may be fortified against inoculation, and by its use a peculiar reaction is produced in those affected by the disease. It is known as *mallein*, and by it are tested all horses used for the preparation of the diphtheria antitoxine, in order that all possibility of glanders may be eliminated. It is probable that it might be made of therapeutic value in treating the disease when actively present in man.

Anthrax.

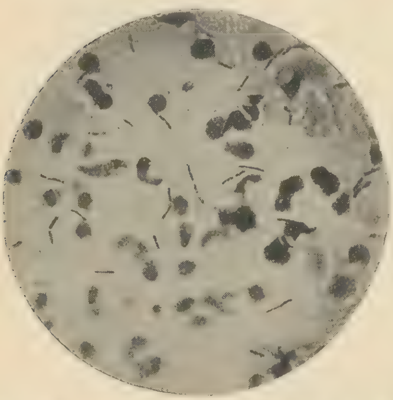
Anthrax is more commonly known as *splenic fever*, *malignant pustule*, or *wool-sorter's disease;* in Germany, as *Milzbrand*, and in France, as *charbon*. It is an infectious disease, which has devastated many parts of Central Europe of cattle, and which has been frequently met with abroad among men, though but rarely in the United States. All the domestic and nearly all the experimental animals are subject to it. Gronin has stated that in the district of Novgorod, in Russia, during four years more than 56,000 cattle and 528 men perished from anthrax. Poultry and dogs are not exactly immune, but possess a low susceptibility to the disease. It seems to prevail in low districts and in marshy grounds.

The terms *anthrax* and *carbuncle* have been variously used, and confusion has at times arisen from this mistake. It would be best always to call the disease by the name *anthrax*, and never to use the term "carbuncle" in connection with it, although in the cutaneous lesions most often seen in man anthrax-pustules assume

the carbuncular type, being accompanied by considerable tissue-necrosis, which may be separated in the shape of sloughs.

The disease is the result of the invasion of the *bacillus anthracis*, which is a relatively large-sized bacillus, varying in breadth from 1 to $1\frac{1}{2}$, and in length from 5 to 20 mikrons. It is most easily cultivated outside the body, and multiplies with great rapidity in the body of susceptible animals, is the type of spore-bearing bacilli, and is so easily recognized and worked with, that it is commonly used in laboratory investigations. The demonstration of its specificity we owe to Davaine in 1873, although he had described it in 1850. The organisms are non-motile bacilli, and reproduce by fission as well as by spores, both of which processes can be observed under the lens. They stain with all dyes, and are easy, though somewhat dangerous, to work with. While the mature organisms are of comparatively slight resistance, their spores are extremely durable and require relatively powerful antiseptic solutions or prolonged heat or the actinic effect of bright sunlight to destroy them. Pieces of thread dipped in a bouillon culture of anthrax, in which the spores form best, are used in laboratory investigations for determining the strength of antiseptic solutions necessary to kill. These are the so-called *spore-threads*.

FIG. 36.



Bacilli of anthrax; from splenic juice of infected guinea-pig; × 500 (Fränkel and Pfeiffer).

Anthrax bacilli may enter the body through the *respiratory organs*, through any *abraded surface*, and possibly even through the *alimentary canal*. They may also pass through the placenta and affect the fœtus *in utero*. They are too large to pass through the walls of the capillaries of ordinary size; consequently, they plug them and produce a mechanical stasis which is rapidly followed by gangrene. From the kidney structures and capillaries, however, they must escape, since bacilli are found in the urine in certain cases of anthrax.

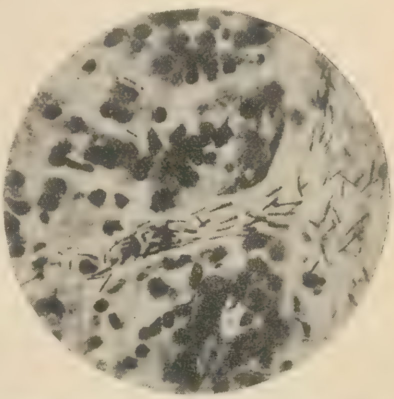
Anthrax bacilli better illustrate the possible mechanism of these infectious agents than any other organisms, save possibly the erysipelas cocci. They may be seen choking the capillaries and completely interfering with all function, thereby determining the death of the invaded part. They produce a toxine of virulent properties of somewhat uncertain strength; and, finally, they are aërobic, and hence secure their oxygen from the tissues in which they grow, thereby robbing them. The spores are so resistant that they remain for an indefinite length of time in the soil upon which carcasses of animals dying of the disease have rested or have decayed; and such fields are dangerous grazing-grounds for cattle for an indefinite number of years thereafter, bacilli being, as Pasteur has shown, brought to the surface by earth-worms. They are also susceptible of being carried dry by the wind, or moist in currents of water, and spread for an indefinite distance, a constant menace to all vertebrate animals that partake thereof.

Anthrax bacilli are capable of attenuation by successive cultivation, also of having their virulence restored by passing through the bodies of animals. These, however, are all points of interest which concern the bacteriologist rather than

the practising surgeon, although the latter must be familiar with the researches of the former.

In *man* the disease occurs usually as the so-called *malignant pustule or wool-sorter's disease*, the latter name being given because of the liability of those individuals who come in contact with the carcasses and hides of diseased animals or their immediate products. The *period of incubation is brief*—on the average two or three days. The first lesion appears usually on the face, hands, or arms, and is characterized by local discomfort with formation of a small papule, which rapidly becomes a vesicle with an areola of cellulitis about it. This is rapidly followed by induration and infiltration, and these by local gangrene, the result being the separation of a core-like mass, much as in certain cases of carbuncle. The affected area is usually discolored, often quite black. The process is not usually accompanied by suppuration, nor is there the pain of true carbuncle. The lesions tend to spread peripherally, but there is more or less vesication of the surrounding skin. On account of the local ischæmia there will always be œdema of the affected region, and sometimes the swelling and local disturbance become extreme. These peculiar lesions have given rise to the common name, *malignant pustule*, which is well deserved. At last a line of demarcation becomes manifest, and if the disease progress favorably the included area is sloughed out, leaving a surface which it is hoped will soon become covered with reasonably healthy granulations.

FIG. 37.



Bacilli of anthrax: section from liver; × 500 (Fränkel and Pfeiffer).

Absence of pain, and usually of pus, are significant features of anthrax. Should, however, mixed infection occur, we are quite likely to get pus-formation. When the disease partakes less of the characteristics of malignant pustule and more of a general infection, the local symptoms may not predominate, but, on the contrary, septic indications may become serious and even fatal. The evidence of more or less toxæmia is usually at hand, however, and the toxine of anthrax is almost as destructive of muscle-cell integrity as is that of diphtheria.

The local lesions may be single or multiple, but will be met with almost always upon exposed areas of the body.

POST-MORTEM APPEARANCES.—These will depend upon the clinical course of the disease. In the sloughing tissues the bacilli are very numerous, while around the margin more than one bacterial form will probably be met with—*i. e.* mixed infection. Should saprophytic organisms complicate the case, they may have replaced the anthrax bacilli by the time the examination is made. The latter abound, however, in the blood, and may usually be found occluding the capillaries of the liver, spleen, kidney, etc. In intestinal infection, particularly in animals, the mesenteric nodes are involved. Inasmuch as septic features

accompany all fatal cases, putrefaction will be found to begin early, and the changes in the blood and the gross changes in the other organs will, for the most part, remind one of sepsis rather than of anthrax.

PROGNOSIS.—Prognosis for man is not usually unfavorable, the majority of cases recovering with more or less local destruction of tissue. Should, however, infection become generalized, the case will probably terminate fatally.

TREATMENT.—This must be both local and constitutional. The former should consist of the most radical possible attack, and should include complete excision of the infected area, with the use of active caustics or the actual cautery. In fact, the latter instrument offers a most valuable means for combating the destructive tendency of the disease. Sloughing and separation of the cauterized mass may be hastened by warm antiseptic poultices. Subcutaneous injections of 5 per cent. carbolic solution have been practised with apparent benefit in a number of cases, but should only be relied upon in the treatment of the milder manifestations.

Benefit will accrue from the use of the ichythol-mercury ointment whose formula I have given when considering the treatment of Erysipelas. It has been suggested to treat these cases by the employment of the bacillus pyocyaneus, since it is known that this organism when injected with the anthrax bacillus materially attenuates its effect.

An albuminose corresponding to tuberculin has been prepared by filtration from anthrax cultures, and a glycerin extract or other preparation of this is found to confer immunity upon many experimental animals and to mitigate the disease in those suffering from it. Pasteur has demonstrated also the possibility of protecting animals by a sort of vaccination with attenuated organisms, and it is demonstrated that animals may in this way be protected from the disease or redeemed from its ravages. It is quite likely that treatment based upon these experimental results will be introduced to combat the disease in man should it ever show more than a tendency to involve solitary individuals.

MALIGNANT ŒDEMA.

This disease has been recognized for some time, mainly by French and Continental clinicians, and under such names as *gangrène foudroyante*, *gangrène gazeuse*, *gangrenous septicæmia*, and *gangrenous emphysema*. The name **malignant œdema** was given by Koch, who identified the infectious organism. It is one of the most dangerous forms of gangrenous inflammation, and occurs sometimes after serious injuries, and, again, after most trifling lesions, such as those inflicted by the dirty pointed instruments of the gardener, etc., or even the stings of insects. Two cases are on record where the disease followed a puncture of the hypodermic needle for the administration of morphine. In one of these the organism was found in the solution; in the other it probably had been deposited upon the skin.

Malignant œdema is essentially a specific form of *gangrene* (see Chapter V.), and is mentioned here rather because of its specific character. It is characterized by rapidity of spread and the specific nature of the exudate, as well as by the speedy destruction of the tissue involved, and by more or less gas-formation. It is not the same as the gaseous phlegmons described by some German surgeons, yet partakes of their general character. (*Gas phlegmons* have been rarely noted, their

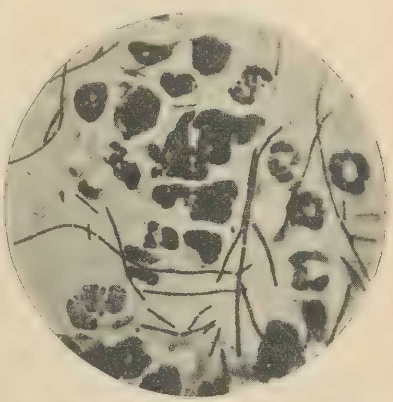
peculiarity being formation not only of pus, but of more or less offensive gases, which escape when the plegmon is incised. The gases are due to the presence of saprophytic organisms, and gas phlegmons, as such, are to be regarded as instances of mixed infection.)

Malignant œdema is known by the brownish discoloration of the overlying skin, which is streaked with blue where the overfilled veins show through it, while the underlying tissues are sodden with fluid and more or less blown up by the gaseous products of decomposition, so that the finger detects a firm crepitus, as is common in subcutaneous emphysema. From the wound, if one there be, flows a thin, foul-smelling secretion, which may also be expressed from the deeper layers. That the neighboring lymph-spaces and nodes are actively involved is evident from the enormous swelling of the latter, as well as from the general condition of the patient. The rapid elevation of temperature with but trifling remissions remains constant until shortly before death. The tongue early becomes dry and cleaves to the palate, its surface being covered with a thick, foul fur. Patients early become apathetic, complaining only of pain and burning thirst. Delirium and coma usually precede death, which may occur in even so short a time as fifteen to thirty hours. After death the cadaver bloats quickly and putrefaction goes on with amazing rapidity.

Post-mortem Appearances.—At the seat of the lesion even muscles and tendons will be found macerated, bone denuded and surrounded by a putrid fluid, the entire region presenting a notable swelling and infiltration of soft parts with reddish fluids and stinking gases. The overlying skin will be stretched, and superficial blisters may deepen the intensity of the process. The veins are clogged with decomposed blood and broken-down thrombi, and in the heart and large vessels will be found putrid liquid as well as gas, to whose presence early and sudden death is probably due.

The *bacillus of malignant œdema* was demonstrated by Koch in 1882. It is the same as the *vibrion septique* of Pasteur. It much resembles in form and shape that of anthrax, yet differs widely from it in that it is motile, but particularly in that it is strictly an anaörobic organism, growing on surface of culture-media only in the strict absence of oxygen. The bacillus of malignant œdema may be found in rich black loam at almost any time, in this respect strongly resembling the tetanus bacillus. In fact, a guinea-pig inoculated with ordinary garden-earth is very likely to display symptoms either of tetanus or of malignant œdema. An interesting case of this disease following typhoid fever has been reported by Brieger and Ehrlich.

Fig. 38.



Bacilli of malignant œdema, from tissue-juice of infected guinea-pig; × 1000 (Fränkel and Pfeiffer).

While this distinct organism produces constant effects in the direction already indicated, there are doubtless other organisms capable under exceptional circumstances of producing analogous disturbances: and it does not follow that every case of gangrenous emphysema, gaseous phlegmon, etc. is necessarily due to this bacillus. I have known personally of one case of extensive gangrene of the integument of the back accompanied with gaseous decomposition which was distinctly not due to this cause.

Prognosis.—This, for the most part, is bad, especially when the bacillus of malignant œdema is alone at fault. Patients may escape

with their lives, but always at the expense of more or less tissue-destruction.

TREATMENT.—This must consist of extensive incision to permit escape of fluids and gases and relieve tension; of such antiseptic applications as can be made available; of immersion of the affected part in a hot antiseptic bath, if this be possible; and of such vigorous stimulation by the most powerful measures—strychnia, alcohol, etc.—as may be possible, in order to support the patient through the period of profound depression characteristic of the disease.

RAUSCHBRAND, OR BLACK LEG.

This is a disease quite common among cattle in Central Europe; it is known to the French as *symptomatic charbon*, and among the English as *black quarter*. Clinically, it pursues a course similar to that of malignant œdema, with this principal clinical difference—that the gases produced in rauschbrand have no putrefactive odor, while those distending the tissues in malignant œdema have. Moreover, the disease is due in this instance also to an *anaërobic bacillus* much resembling that of gangrenous œdema, although there are minute differences between the two organisms. It is known also that one attack of rauschbrand confers immunity, which fact is not yet established for malignant œdema. It has been established also that the organism is capable of transmission from mother to fœtus, and that protective inoculations can be performed much as in the case of anthrax. With some of the animals at least the rauschbrand bacilli can be intensified in action by mixture with the bacillus prodigiosus.

FIG. 39.

Bacillus of rauschbrand: from pure culture showing spore-formation: × 1000 (Fränkel and Pfeiffer).

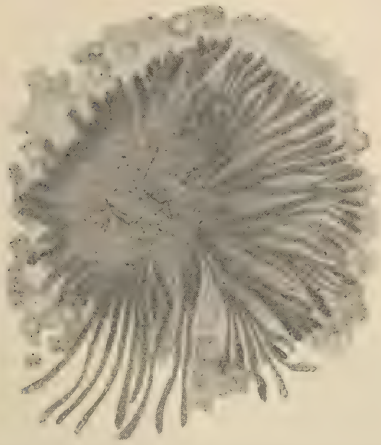
ACTINOMYCOSIS.

This also is a *subacute*, but always *destructive infection by a specific micro-organism, though not a bacterium*. Known always as *actinomycosis* in man, the disease, which is most common in cattle, has been known commonly as **lumpy jaw** or *swelled head*, and years ago was usually regarded as cancer or as a malignant affection.

Many old museum specimens labelled as cancer of the tongue, jaw, etc. have of late been shown to be instances of actinomycosis of these parts. It is occasionally met with in man, so that now there are probably at least three hundred cases on record in this country and in Europe. The organism was recognized some fifty years ago by Langenbeck and Lebert, but was not scientifically described until thirty years later. The names of Bollinger, Israel, and Ponfick will always be connected with these researches.

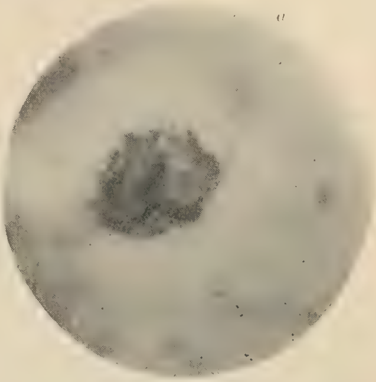
The organism itself belongs among the *ray fungi*, is known as the *actinomycis*, and occupies a somewhat uncertain place in classification. It is large enough, when entire, to be noted by the naked eye, has ordinarily a yellowish tint, a tallowy consistence, and may be seen under the microscope to consist of a cluster of branching prolongations, club-shaped at the end, radiating from a common centre. They give it rudely

Fig. 40.



Actinomycosis bovis, from sections of a "lumpy jaw," showing ray fungus (Crookshank).

Fig. 41.

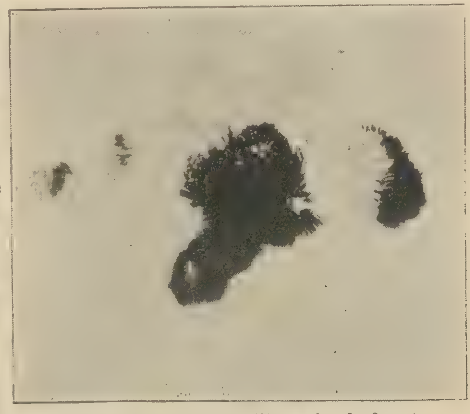


Actinomycis, from liver of a male patient: *a*, rays of fungus ($\frac{1}{12}$ oil immersion).

a sunflower appearance. It is stained with difficulty, best with a combination of picrocarmine and some aniline dye. In tissue-sections the Gram stain is the best. It is cultivated with difficulty, but can be grown upon solid media and may be inoculated.

As met with in tissue or in pus, these fungi constitute small granulations, giving usually a gritty sensation to the finger, which is due to the presence of calcium salts. The recognition of this calcareous material is of great importance, since it may enable a diagnosis to be made offhand which otherwise might puzzle one. In the only case so far met with by the author the diagnosis was established within a minute by the detection of these little particles.

Fig. 42.



Actinomycis, from submaxillary gland of a steer ($\frac{1}{12}$ oil immersion).

The disease is very common among cattle in certain regions, and causes the condemnation of many animals in every large stockyard establishment where inspection is careful and scientific. It occurs oftener in young than in old animals, and most often in those which come from valley regions and marshes. In animals infection occurs almost invariably through the mouth, which

is easily explained by the fact that in grazing the lips, tongue, and gums are likely to be irritated and infected at any time from soil containing these fungi along with growing grain. The path of infection, then, is usually by the mouth, while accident seems to determine whether the infection shall manifest itself mainly in the intestinal canal or the respiratory tract. In animals there is less tendency to suppuration than in man, the infection in man being usually a mixed one. The name *lumpy jaw*, so generally given to the affection, is indicative of the most conspicuous lesion in cattle, for the organism, having once invaded the gum, for instance, passes quickly to the bone, or, having involved the tongue, is not slow to infect the lymphatics of that region. In consequence we have tumors, often of inordinate size, which may involve the bones or the soft parts and cause great disfigurement, along with necrosis, leading eventually to the death of the animal. These tumors are essentially *granulation-tumors* due to the presence of a specific irritant—namely, the *actinomycis*—which acts here as do the tubercle bacillus, the lepra bacillus, etc. in other infectious granulomata.

In man the disease is almost always accompanied by abscess-formation, the pus containing the distinctive yellow gritty particles which are found in no other disease. The strong resemblance between the lymphoid cells of this form of granuloma and the embryonal cells of sarcoma has

FIG. 43.

Actinomycosis bovis (Crookshank).

permitted the perpetuation, until recently, of confusion between these two neoplasms.

Large abscesses form as the result of the coalescence of small ones, and by the time the disease is recognized extensive destruction and loss of substance may have taken place. In man it is not alone about the mouth that the disease is noted, although primary lesion here is by no means infrequent. It leads to affections similar to that already spoken of in cattle, with a progressive infiltration and breaking down, including actual necrosis of bone, etc. The pus will escape at various points, and may give to the surface an appearance as of many craters with a central cause. When the disease has involved the lung, either directly or indirectly, the fungi and the calcareous particles may be found in the sputum. Should there be suspicion of this involvement, the

sputum should always be examined. Even in the heart-substance tumors of this same character have been found. The first case noted in man had undergone extensive vertebral caries. Intestinal infection is possible, in which case multiple lesions will form in the intestinal walls, which may contract adhesions to the abdominal parietes and discharge externally through them. The appendix has been found involved in such lesions. Infection of the skin has also been described, though this occurs more rarely.

DIAGNOSIS.—Actinomycotic lesions have been in time past *mistaken for cancer, sarcoma, tuberculosis, syphilis*, etc. Without going more minutely into differences, it is enough to say that in man it will always be characterized by more or less suppuration, and that in the purulent discharge from the infected focus the characteristic yellow calcareous particles should enable recognition of this disease at once.

FIG. 44.

Actinomycosis in man (Musser).

PROGNOSIS.—So long as the focus is accessible it is a purely local matter, and prognosis is as favorable as in local tuberculosis; but, inasmuch as in too many cases infection has proceeded to a point where the surgeon cannot safely follow it, prognosis must be guarded. Actinomycosis is free from acute manifestations, for the most part free from pain, pursues a chronic course, and is characterized, as are the other slow infections, by progressive emaciation, prostration, etc. Inasmuch as it is essentially a chronic condition, time is afforded for careful study in doubtful cases, for microscopic examination, etc.

TREATMENT.—This must consist of radical extirpation of all infected tissues and areas. If this can be done thoroughly, and safely in other respects, one may hold out a prospect of positive cure. Free incision, wide dissection, the use of the actual cautery, etc. are always called for in these cases. If it involve the tongue alone, for instance, there is an excellent prospect; if but a portion of the jaw be involved, a complete excision of one-half or more may be followed by excellent results. If, however, the lung, liver, vertebræ, or other vital and inaccessible parts be involved, surgical measures may afford amelioration, but can hardly be expected to cure.

CHAPTER IX.

SURGICAL DISEASES COMMON TO MAN AND THE DOMESTIC ANIMALS (CONTINUED).

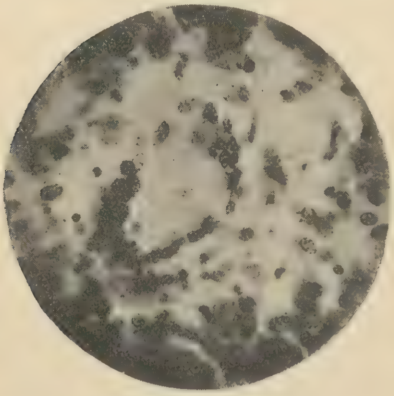
By ROSWELL PARK, M. D.

TUBERCULOSIS.

THE most important and frequent of the infectious diseases common to animals and man is **tuberculosis**. This is, for the most part, a subacute or chronic affection, although in a small proportion of cases it assumes an acuteness of type which may make it fatal within so short a time as fourteen or fifteen days from the first recognizable symptom or even less. Tuberculosis as a form of disease is more prevalent than any other, and is the cause of death of a proportion variously estimated at from 20 to 30 per cent. of mankind. It is a disease which intimately concerns the surgeon, perhaps even more than the physician, inasmuch as it is also the most common of all the so-called surgical diseases. The frequency with which it is met varies in different parts of the country, and in some measure with the character of the population. In the average surgical clinic of the United States probably 25 per cent. of cases of surgical disease are manifestations of this affection.

Surgical tuberculosis now covers the entire range of disease-manifestations formerly inaccurately and inaptly described as *scrofula*. The term scrofula is now expurgated from medical terminology, and there is no longer any excuse for its continuance, save possibly in making certain explanations to the laity, who are not yet educated to the new term. All of the active manifestations formerly regarded as scrofulous are now known to be due to tuberculosis.

FIG. 45.



Section of tubercular liver, showing bacilli; × 500 (Fränkel and Pfeiffer).

Our views with regard to tuberculosis have been completely revolutionized within the past twenty years, since the specific nature of its cause has been established, and the distinctions made in the old text-books between yellow and white tubercle, etc. are now relegated to the oblivion which they deserve. Since the inoculation-experiments of Villemin in 1865, who first demonstrated the inoculability of tuberculous products, and the epoch-making discovery of Koch, who in 1882 established beyond cavil the parasitic nature of the disease, the views and descriptions of the old writers have had to be entirely revised. The infectious character of the disease is now so well established that the chain of evidence was years ago regarded as complete. The tubercle bacillus (*bacillus tuberculosis*) is a thin, rod-shaped organism, from 3 to 4 mikrons in length (averag-

ing in length half the diameter of a red blood-corpuscle), often slightly curved, with ends usually rounded. It is often found in pairs, arranged in V-form, sometimes in chains. Spore-formation is the exception, the organisms usually dividing by fission. Free spores are never observed, although when properly stained the bacilli exhibit spots which seem to indicate spore-formation. The organism seems to possess a quite tough cell-wall or capsule, which enables it to pass through the entire alimentary canal without destruction by the digestive juices, and which gives it a vitality that permits existence outside the body for a considerable length of time. It is a facultative anaërobe, growing either with or without oxygen. It has a distinctive manner of taking stains which enables its recognition and differentiation from other forms. In cultures it grows very slowly at body-temperature.

To the presence of tubercle bacilli in the tissues is due that distinctive aggregation of cells which constitutes the so-called **miliary tubercle.** Its presence and arrangement is apparently the direct outcome of the irritation produced by these minute foreign bodies, and its method of grouping is so characteristic that it may be everywhere and usually easily recognized. Its centre is composed of one, possibly several, *giant cells*, whose nuclei are usually arranged around the margin, with perhaps degenerative changes going on in the interior of the cell itself. In this giant cell, as well as outside of it, may be seen one or several *tubercle bacilli*. Around this centre are clustered a number of large cells, known as *epithelioid*, which may also contain bacilli. These cells are probably

Fig. 46.

Synovial membrane with tubercles; × 70: giant-cell in the middle of a sharply outlined tubercle; about it round-cell infiltration (Krause).

derived from epithelium when at hand, or from the endothelium of the vessel-walls, or from the fixed tissue-cells. Outside of this are yet other, usually spindle-shaped, cells, contained in a connective-tissue network and regarded usually as *lymphoid cells*. When tubercle is experimentally produced the bacilli seem more numerous than they do in instances of spontaneous disease. This little aggregation of cells constitutes a mass which may be recognized by the naked eye—a minute, usually white point or nodule, which is known as a *miliary tubercle*. It is subject to any one of several changes to be presently considered, and it is usually found in large numbers when present at all. The punctate appearance

of miliary tuberculosis is perhaps best seen upon the cerebral membranes or the peritoneum in cases of acute miliary tuberculosis. By coalescence of a number of these nodules larger tubercles are formed, and by combination of coalescence and caseous degeneration are produced the large cheesy masses which our forefathers called *yellow tubercle.*

FIG. 47.

Tuberculosis of serous membranes [tunica vaginalis testis]; round-cell infiltration (Goldmann).

The epithelioid cells are by some regarded as modified leucocytes; by yet others, as the product of division of the fixed cells. The giant cell is probably the result of irritation in one of these cells, the stimulus being sufficient to provoke division of the nucleus, but not of the entire cell. Since the principal cellular activity occurs in the interior of this nodule, the result is a condensation about the periphery which furnishes eventually a sort of capsule, as it were, the tissues being hardened and condensed as if for this special purpose. The effect of this is to interfere with vascular supply, and finally to completely shut it off. So long, now, as no pyogenic infection occur, the original tubercle may gradually shrivel down and disappear, or, most likely, caseous degeneration will occur, and it may persist as a cheesy nodule for an indefinite length of time. As such a tubercle grows old the cells lose their identity, refuse to take stains, and a slow or quiet coagulation-necrosis results. In this nest sometimes calcium salts are precipitated, the result being a *calcareous nodule.* On the other hand, during the active stage of this tubercle-formation cell-resistance may be lowered, either from general or constitutional causes; the original focus disintegrates; tubercle bacilli are liberated, and are now carried hither or thither, *metastatic tubercles* being the result of their dissemination.

Spontaneous healing of tubercle is possible, and may be due to three different causes:

(*a*) Necrosis and exfoliation of diseased tissue (*e.g.* in lupus);
(*b*) Cicatricial formation;
(*c*) Retrograde metamorphosis.

Looked at from another point of view, the possible fates awaiting the miliary tubercle are the following:

(*a*) *Absorption;*
(*b*) *Encapsulation;*
(*c*) *Cheesy Degeneration;*
(*d*) *Calcareous Degeneration;*
(*e*) *Suppuration.*

Absorption of tubercle undoubtedly is possible under favorable circumstances, but just what constitute these favoring circumstances no one knows, since they occur in cases which do not terminate fatally. To be able to describe them would be to detail minutely the changes

which permit of recovery after non-traumatic tubercular infection; which clinical fact is amply demonstrated by the experience of the profession. Absorption is probably largely a matter of phagocytosis.

Encapsulation has already been spoken of, the capsule being formed by the condensation of the original cells of the tubercular agglomeration, the infectious organisms being thereby imprisoned so long that they are practically starved, and finally die. The tubercle bacilli, however, may long lie latent in such a cellular prison, and should anything occur to break the prison-wall, they may escape and still prove actively infectious. In this way are to be accounted for the fresh eruptions from old miliary or other deposits.

Caseation is a condition more fully to be described in works on pathological anatomy. It comprises a series of changes in the chemical constitution of the cells by which an albuminoid mass much resembling casein in composition and appearance is produced. The English equivalent *cheesy* well describes many of these masses, which both cut and appear very much like domestic cheese. They have a yellowish color, and are met with in masses in size from a pin's head up to a robin's egg. These are the yellow tubercles of the older writers, and such a cheesy tumor has been called *tyroma.*

Calcification refers to a peculiar deposition of calcium salts within the interior of these nodules, the first precipitation occurring usually in the centre of the giant cell, which is itself the topographical centre of the miliary tubercle. As time goes on it may spread from this, until a mass easily recognizable by the naked eye and detectable by the finger is produced. Such calcareous particles are frequently found in sputa, and are always an index of the tuberculous character of the case. They differ markedly from the yellow calcareous nodules found in the pus of actinomycosis, and the only circumstances under which they are likely to be confused are met in pulmonary disease, which may prove to be either one or the other.

Cold Abscess.

Suppuration, as indicated, is the result, for the most part, of a mixed or secondary infection with pyogenic organisms. I have in the previous chapter grouped tubercle bacilli as among the facultative pyogenic bacteria, yet I must say that, for the most part, pus is not formed in this disease except in consequence of coincident activity of other bacterial organisms. The matter of suppuration of tubercular foci is one of the greatest importance to the surgeon, because thereby is produced a distinct class of so-called abscesses—namely, the *cold* or *congestion abscesses.* These, as usually coming under the surgeon's notice, are of the chronic type, and are free from almost all the ordinary signs of abscess-formation. They are invariably the result of local infection, sometimes perhaps by the tubercle bacilli alone, but most often by combined action of these with pyogenic forms. For their formation a previous tubercular lesion is essential, and such is always met with. Wherever old tubercular lesions are met with, there may cold abscesses also form. No tissue or organ is exempt: they are found in the brain, in the bones, viscera, joints, skin, and everywhere.

Cold abscesses have not only a significance of their own, but for the most part an identity. Their most distinguishing feature is a *limiting membrane,* which forms whenever sufficient time has elapsed. Much has been written about this in time past, and much error has been perpetuated with regard to it. This is the membrane formerly considered and

FIG. 48.

Pyophylactic membrane dotted with tubercles containing giant-cells ; × 70 (Krause).

called *pyogenic,* under the misapprehension that by it the pus or contents of the abscess were produced. I wish to emphasize in every possible way that this is a sad error. This membrane does *not* act to produce pus, but is rather the result of condensation of cells around the margin of the tubercular lesion, forming, as it were, a sanitary cordon for the absolute and definite purpose of protection against further ravages. I therefore insist that the term pyogenic membrane be abolished, there being no such membrane under any circumstances, and that this be known as that which in effect it is—namely, a **pyophylactic membrane.** *It is a protection against pus,* and, were it not for its presence, there would be no limit to the spread of tubercular invasion. As it is, a lesion thus surrounded is shut off from most possibilities of harm, rarely encroaches, except by the most gradual processes, and, on the contrary, often contracts and reduces its dimensions, the watery portion of its contents being gradually absorbed and the more solid and cellular portions becoming condensed, finally, into matter which undergoes caseous degeneration, so that eventually recovery may ensue as the consequence of a metamorphosis of an original cold abscess into a caseous nodule surrounded by the old pyophylactic membrane, which is now serving as a capsule.

The contents of the cold abscess are, in some instances at least, of rather acute origin, and consequently may have been originally pus or its near ally. Upon the other hand, in cases which have occurred very slowly this material never is, and never was, real pus, but is a semifluid débris having certain properties which remind one of pus. It has been my effort hitherto to devise for this material a name which should distinguish it from pus and indicate what it really is. Inas-

much as most of it has been of a puruloid character, at least at one time, I have suggested that it be called *archepyon* (*i. e.* originally pus or puruloid). As this flows from such a cold abscess, it is more or less watery and contains caseous, sometimes calcareous, nodules in masses of considerable size, and not infrequently sloughs of tissue and old shreds of white fibrous tissue which resist decomposition for a long time. This material has been thus imprisoned, sometimes for months or even years, and consequently has lost most of its resemblance to what it originally was. The organisms which first produced it have long since died out, and it is practically sterile. If any organisms survive, they are the tubercle bacilli, which are very much more resistant and tenacious of life than the ordinary pyogenic organisms. This is why most culture-experiments fail, and why even inoculation with the contents of an old cold abscess is often without effect even on most susceptible animals. *Nevertheless, the bacilli which the semifluid contents do not contain, may yet linger in the meshes of the pyophylactic membrane; and here lurks the greatest danger in dealing with these lesions.* In order to incise and expose them, opening must be made through tissues as yet uninfected and down upon tissues where may still lurk the living, though apparently inactive, organisms. Transplanted, however, into fresh living tissue, they may there attach themselves and bring about a fresh local infection. This is the explanation for many lesions and untoward events so bemoaned by surgeons of previous generations. For example, the majority of anal fistulæ are essentially tuberculous sinuses. When treated by the old method of simple incision without disposal of the infective membrane, the result was simply to expose a fresh wound to a new infection; and it is not strange that certain consumptive and other patients were made worse and had their lives shortened in this way. On the other hand, if such a lesion as this be treated not merely by incision, but by radical extirpation of the whole tubercular focus down to fresh and normally-bleeding tissue, and if such an operation be thorough, or, when it cannot be thoroughly done, if the cavity be thoroughly cauterized with a powerful caustic, we may then see a fresh crop of granulations appear after separation of the sloughs, or in the former instance we may get perfect primary union by suitable apposition of the parts; and all this without re-infection and without anything but resulting good to the patient.

FIG. 49.

Psoas (cold) abscesses displacing other tissues (Lannelongue).

In old cases the pyophylactic membrane is very tough and very adherent by its outer surface. It can sometimes be peeled off in strips of considerable extent, at other times cannot even be separated, or sometimes is so placed as to render it impossible to follow it to its termination. *Complete extirpation of this membrane*, or at least complete destruction, is the duty of any one who attacks such a tubercular lesion; and when its complete removal is impracticable, failure to remove it should be atoned for by some powerful caustic, such as zinc chloride, nitric acid, caustic pyrozone, or the actual cautery, which shall be made to follow it to its ultimate ramification. The membrane and the tissues underlying when thus cauterized will separate as sloughs, and these will be replaced by presumably healthy granulations, which should be encouraged until the original cavity be filled or the surface healed over.

In a general way, then, it may be said that acute abscesses, as indicated in the previous chapter, have no real limiting membrane, although there is more or less condensation of tissues about the focus of infection. A typical membrane is distinctive of tubercular abscesses, and is to be regarded always as their natural protection and a barrier against their further encroachment—nevertheless, a membrane whose inner surface may harbor still active organisms, which yet cannot escape through its outer texture. Consequently, to simply incise it or inefficiently scrape it is to do a worse than useless thing; and one should never attack it unless he is prepared to thoroughly extirpate it or destroy its integrity, and in this way finally dispose of it.

Cold abscesses, when near the surface, cause a bluish or dusky discoloration of the overlying skin, while the superficial and subcutaneous veins of this region are usually enlarged. Fluctuation is also a prominent phenomenon in connection with them when they can be palpated. Deep collections of this kind may be mistaken for cysts or tumors, in which case the aspirator needle may be used to facilitate diagnosis. They vary in size from the smallest possible collection of fluid to abscesses which may contain a gallon or more of puruloid material or archepyon. They are known often as *gravitation-abscesses,* because by the mere weight of the contained fluid they tend to elongate or spread themselves in the direction in which gravity would naturally carry a collection of fluid. Thus, cold abscesses originating from tubercular disease of the lower spine frequently work their way along the psoas muscle and present below Poupart's ligament as *psoas abscesses,* or elsewhere about the thigh, while those which come from similar disease of the uppermost cervical vertebræ may present behind the pharynx, as the so-called *retropharyngeal abscesses;* and those from the dorsal spine present not infrequently as *lumbar abscesses.* These are but two or three familiar examples of what may occur in any part of the body.

Treatment.—Aside from the treatment of cold abscesses, already indicated, by radical measures, other means have been suggested, and particularly for the treatment of those in which such extreme measures are impracticable or simply impossible. It is sometimes efficacious to simply tap or remove by aspiration the contents of such a cavity. It may never refill, or but slowly, and after repeated tapping alone a very small percentage of such cases will subside into inactivity and the lesion be subdued, if not absolutely cured. Of late treatment by injection of solutions or emulsions of iodoform has been quite generally accepted.

This is based upon the alleged specific properties of iodoform as being peculiarly fatal to tubercle bacilli, presumably by liberation of free iodine. A cavity to be thus treated should be first emptied as completely as possible, after which may be thrown into it a glycerin emulsion or an ethereal solution, or a suspension in sterilized oil of iodoform, usually in strength of 5 to 10 per cent. From 25 to 200 c. c. of some such preparation is introduced, while the walls of the abscess are more or less manipulated in the endeavor to completely disseminate the mixture. The cannula through which it has been introduced is then withdrawn; and this can usually be done without any, or at most with but little, unpleasant iodoform effects. This is due to the pyophylactic membrane, which limits the activity of the iodoform, as it has done that of the previous contents of the abscess. Such cavities have also been treated by washing out through a trocar with an injection of various antiseptic or stimulating solutions, among which we may mention hydrogen peroxide, weak iodine solutions, etc. My own advice is to treat all tuberculous lesions radically when such measures are not contraindicated by their multiplicity or by

too great depression of the patient, and so long as lesions are accessible to ordinary operative procedures. This same advice pertains also to those which have already spontaneously evacuated themselves or where the overlying skin is threatening to break and permit escape of contents. Almost any case where this is imminent is one in which the surgeon, as such, ought to interfere. On the other hand, in deep collections and in debilitated individuals the treatment by injection may at least be tried.

With added years of experience my conviction has grown, however, that the best way in which to treat accessible tubercular lesions is by the most radical and merciless extirpation, and that, while this subjects patients to operative ordeals, it nevertheless shortens the period of time during which they are under treatment, hastens convalescence, and leads to very much more permanent results.

The Gummata of Tuberculosis.

The other and essential characteristic of tubercular disease, by which it manifests itself in surgical lesions at least, is the infectious granuloma to which it gives rise. This is a term first applied by Virchow to new formations of granulation-tissue, which are the result of the presence of an invading and specific irritant. This tissue varies little in type, if at all, from that already described when dealing with the healing of ulcers, and is common to the neoplasms which are met with in tuberculosis, syphilis, leprosy, glanders, and some of the other local infections. So little does the tissue-type vary in these different instances that it is difficult, if not impossible, to distinguish by microscopic sections of the unstained tissues, or at least those unstained for bacteria, to which class of lesions they belong. The production of granulation-tissue is, however, of such general prevalence and such important significance that it must be spoken of at some length in this place.

This tissue may be met with in any of the tissues of the body, but is seen perhaps least often upon the serous membranes of the cranial and peritoneal cavities, whereas in the joint-cavities it is common. It is provoked, as just stated, by the presence of tubercle, and has the power of penetration into and substitution for almost all the other tissues of the body. Thus in a primary tubercular focus within the bone a granuloma will form and extend its limits, while the surrounding bony tissue melts away before it; and it is by the growth of this tissue in a particular direction that tubercular products from within the bone-cavity are finally carried to the surface. When this material has escaped from bone or from tissues without the bone toward the surface, its presence is marked by induration, by livid discoloration of a limited area of skin, with elevation of the surface, which finally breaks down and shows discolored, bleeding, and pouting granulations, which in the absence of restraint now proliferate more rapidly, and often to the point where they get away from their own blood-supply, and consequently necrose upon the surface. This is the *fungous granulation-tissue*, especially of the German writers, and may be met with upon the surface, or is frequently seen in opening into joint-cavities and other tissues infected by tubercle. The appearances of this fungous tissue are modified somewhat by environment and pressure: in joints flat and radiating, masses of it will be found, extending along the synovial surfaces and into the articular crevices. This fungous tissue may grow in any direction, but apparently always does advance in the direction of least resistance. It leads to complete perforations of the flat bones, like those of the skull, while tuberculous masses from the dura may cause multiple perforations, the granulation-tissue finally escaping through the overlying skin. In tuberculosis of synovial sheaths and bursæ it extends along, and may completely fill and even distend, them. It will separate tissues which are united together, and it may lead to disintegration and disorganization of the firmest textures in the body. So long as it be not exposed to the air nor to pyogenic infection it will preserve its characteristics for a con-

siderable length of time. Immediately upon exposure it is likely to break down, and infection will travel speedily along it into the deeper cavity whence it has sprung. A mass of this tissue contained within the normal tissues, condensed more or less by pressure, uninfected, and not freely supplied with blood, is entitled to the name of **tuberculous gumma**, whose tendency, however, is for the most part to break down and suppurate. Such gummata may be found in any part of the body, and differ only in unessential respects from the diffused and more or less infiltrated masses of granulation-tissue which occupy serous cavities or which extend in various directions.

The lesions of surgical tuberculosis, except those already spoken of as constituting cold abscess, are so essentially connected with the presence of granulation-tissue, just described, or of this form of the infectious granulomata, that no student can appreciate the subject until he is quite familiar with this tissue in its various phases and in various locations. Of such great importance is it that this be realized that some of the local manifestations of this new tissue must here be considered, although they may be rehearsed in other form in succeeding chapters.

FIG. 50.

Lupus of hand, tubercular disease of bones, with absorption (Krause).

FIG. 51.

Epithelioma developing upon lupus—"lupus-carcinoma" (Steinhauser).

In the skin and subcutaneous tissues and **in and under mucous membranes** this granulation-tissue may be studied at places where it is free from most of the mechanical restraints to growth, and where in other respects its appearances are typical. The most characteristic manifestations in the skin occur as **lupus**, a disease for a long time considered cancerous or of uncertain etiology. We are in position now to teach, however, that lupus is always a cutaneous manifestation of this protean disease.

In its incipient stages lupus consists of multiple minute nodules of granulation-tissue just beneath the surface, containing all the elements of true miliary tubercle,

with infiltration of the surrounding skin, even into the subcutaneous fat. The most common location of these lesions is on exposed surfaces. Bacilli are not numerous, yet may be demonstrated in all these lesions. The tendency is more or less rapidly to break down, the result being a tubercular ulcer, which, as it extends, manifests usually a disposition to cicatrize in the centre while enlarging around its periphery. The dermatologists describe several different forms of lupus under the names *hypertrophicus*, *vulgaris*, *maculosus*, etc., all of which are essentially the same in character, the differences being largely constituted by the rapidity or slowness with which the granuloma of the skin breaks down. From the surface these growths may extend and involve parts at considerable depth, even the periosteum. This name should also include the lesions described as *scrofuloderma* or scrofulous ulcers of the skin, they being all of the same real character.

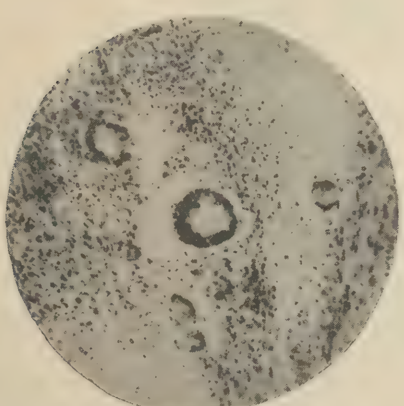
A variety known as *anatomical tubercle* has been described by numerous writers, found especially upon the hands of those who haunt dissecting-rooms or handle dead bodies, and is supposed to be the result of local inoculation. It appears usually as a warty growth, which ulcerates and becomes covered with a scab—is usually most indolent in character, but is followed by lymphatic involvement, and in rare instances by death from tubercular disease.

Any lesion of the skin—puncture, abrasion, etc.—may be infected and become a tuberculous sore. Thus, ears punctured for ear-rings have become diseased in this way.

On the mucous membranes primary lupus is rare, usually spreading there from a skin surface. Nevertheless, distinct forms of it may be noted in the pharynx, in the nose, etc. In fact, tubercular disease of the nasopharynx is quite often mistaken for malignant disease, but will almost always clear up on proper treatment. Upon the tongue, in the larynx, in the rectum, and on other mucous surfaces distinct tubercular lesions are occasionally seen, always partaking, however, of the granulomatous characteristics already described.

In the lymphatic structures and lymph-nodes tuberculosis is a most frequent affection. In these localities it may occasionally be primary, but is almost always a secondary lesion. It is in separating from the lymph-stream the tubercle bacilli, which would otherwise be passed into

FIG. 52.



Tuberculosis of mesenteric lymph-node; × 200 (Fränkel and Pfeiffer).

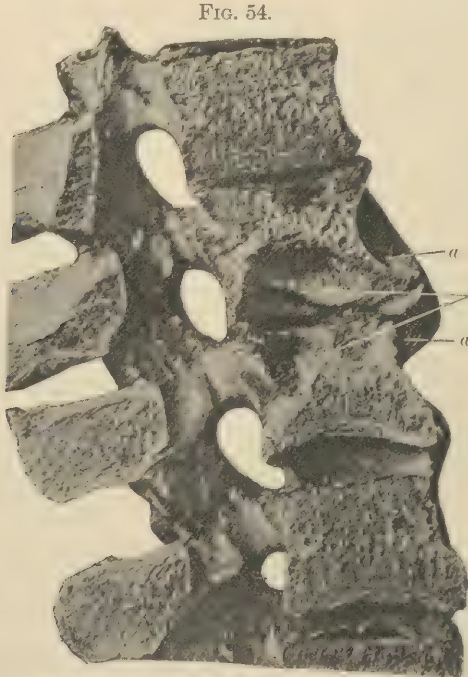
FIG. 53.

Tuberculosis of cervical lymph-nodes (Holloway).

the general circulation, that the lymph-nodes, acting as filters, render us the greatest possible service. These filters, however, almost always become themselves infected, and, enlarging, they assume the appearances

known to the laity as *scrofula*, which in time past have been so generally spoken of as *scrofulous glands*. These lesions abound rather about the axilla and the cervical and bronchial nodes than about the lower extremities. Nevertheless, the retroperitoneal, mesenteric, and inguinal nodes are occasionally infected. In these nodes will be found giant cells surrounded with epithelioid cells, containing bacilli and undergoing cheesy degeneration or suppuration. Infection often proceeds from centre to periphery, and then to the surrounding tissues, the filter, as such, having become so choked that nothing seems to pass it. By virtue of this surrounding infiltration (which used to be known as *periadenitis*, when lymph-nodes were spoken of as *lymph-glands*) generalized infection is in some measure prevented, while the natural barriers are altered and natural distinctions between tissues are lost. This makes complete extirpation of these tubercular foci often very difficult, while the adhesions which they contract, for instance, in the neck are often to the large vessels and nerve-sheaths, by all of which their operative treatment is naturally complicated. When infection from the superficial nodes extends toward the surface it is easily recognized by the dusky hue of the overlying skin, the hardness, infiltration, and, later, the fixation, of these masses, accompanied usually by evidences of suppuration.

FIG. 54.



Tubercular spondylitis (caries): *a*, osteogenesis and osteosclerosis; *c*, cavity formed by degeneration of tubercular focus (Krause).

In the bones we find as often as anywhere expressions of tubercular disease. Strange to say, it is not much more than fifty years since Nélaton called attention to the frequency of these intraosseous lesions,

and demonstrated the essentially tuberculous character of much that had hitherto been overlooked or considered under that vague term scrofula. All those forms of bone disease comprehended under the names *Pott's disease, spina ventosa, tumor albus,* etc. are now known to be distinctly tubercular lesions. In many instances these follow the slight circulatory disturbances brought about by contusions, sprains, etc. This is especially the case in those who are predisposed to this disease.

Tuberculosis of bone always assumes the phase of miliary lesions, followed by the formation of a granuloma, which may gradually encroach upon surrounding tissues or may assume a more fulminating type and spread rapidly. Apparently because of the circulatory conditions, these lesions are most common near the epiphyseal lines of the long bones, seeking seemingly the ends of the bones, as pulmonary lesions seek the terminations of the lungs. These lesions may be solitary or multiple. Beginning always minutely, they spread so as to produce foci perhaps even two inches in diameter. As the result of the formation of

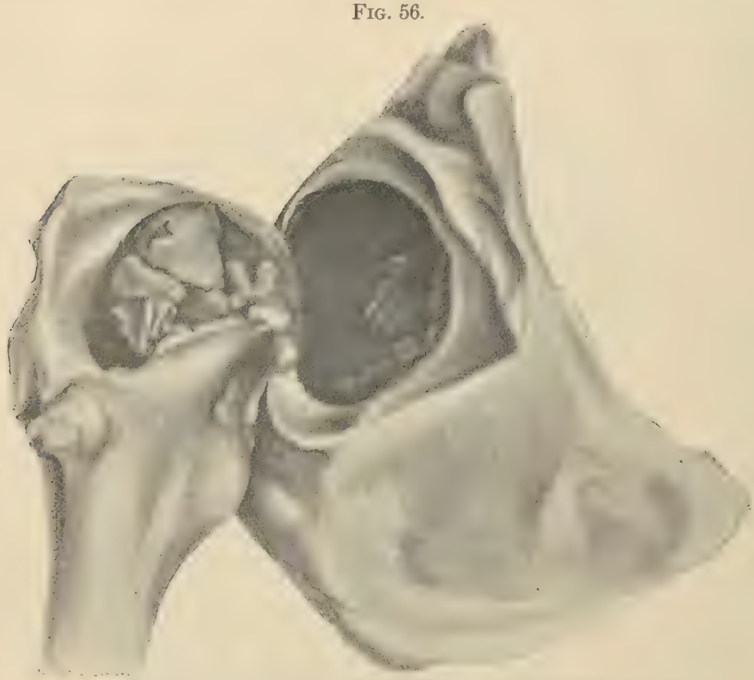
FIG. 55.

Section through upper end of femur, showing osteosclerosis in line of pressure, with alteration in shape—*i. e.* flattening of head and widening of neck.

granulation-tissue, the surrounding bone melts away and disappears, the result being a great weakening of its structure and expansion of its dimensions in order to make room for the growing mass within. The tendency of this granulation-tissue thus imprisoned is always to escape in the direction of least resistance. This carries it sometimes into the joint, sometimes out through epiphyseal junctions, and sometimes through channels in the bone made by its own pressure, with external escape and appearance of the dusky distinctive tissue, felt beneath and then upon the skin. Where bone is so weakened in one direction it is usually strengthened by compensatory deposition of calcium salts at other points, and the

result frequently is a striking *combination of osteoporosis* in the immediate presence of the disease, with *osteosclerosis*, sometimes to a remarkable degree, even to *eburnation*, of an adjoining portion. When this mass undergoes caseous degeneration, the progress of the disease is much slower and the pain less. When it undergoes suppuration, there are more evidences of inflammation, with more pain and systemic disturbance, as well as local swelling, tenderness, etc. The surrounding musculature is rarely involved, although the periosteum is nearly always so. In fact, it is stated that in an inflamed and suppurating bone-lesion, if the muscles are extensively invaded, it may be regarded as of syphilitic rather than of tubercular origin. The *pyophylactic* membrane already alluded to is seen in almost every instance of tubercular disease. The spina ventosa of old writers refers to the expansion of the shaft and medullary cavity of a long bone whose interior is occupied by a mass of tubercular gumma, which is perforated at one point, and through which opening it escapes as does lava from a crater to involve the structures on the outer side. The appearance of this granulation-tissue in joints as *fungous tissue* has already

FIG. 56.



Tuberculosis of hip (coxitis); disintegration and destruction of bone.

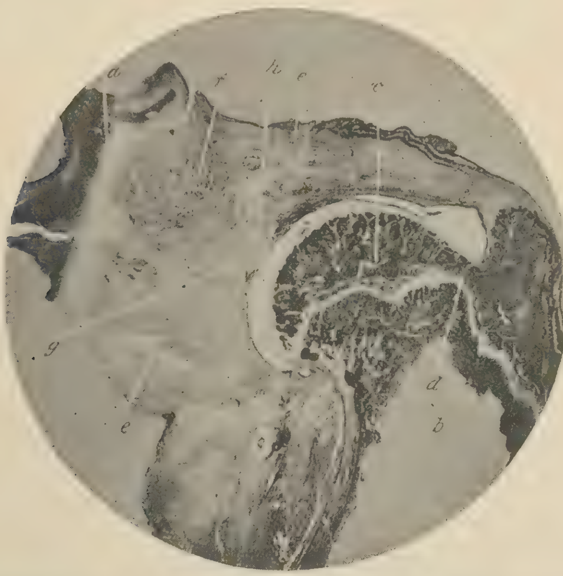
been alluded to. In a general way it preserves its fungoid characteristics until attacked by pyogenic or saprogenic organisms, when it quickly breaks down, forming an ulcer if upon the surface, or a cold abscess if not externally open. Tubercular disease of the bone is most common in the young, and in them the majority of tubercular joints are those whose bony structures have been first involved. In other words, the majority of cases of tubercular pyarthrosis are due to primary bone disease. As the result of the tubercular infection the bones become distorted, best illustrated in Pott's disease of the spine; while, as the result of the constant irritation, joint-ends become displaced by chronic muscle-spasm, and joint-contours entirely altered by expansion of the affected bone and thickening and infiltration of the overlying soft parts.

I have often, for the sake of illustration to medical students, drawn a certain analogy (following Savory) of the gross resemblances between lungs and bones in their behavior when involved in tubercular disease. In either case the structure is in a measure spongy and contains cavities and networks of tissue; in each case

the structures are invested by a resisting membrane—in the one instance, pleura, in the other, periosteum. Again, each is closely related to a serous cavity—the lungs to the pleural cavity, the bones to the serous cavities of the joints. Tubercular disease manifests a predilection for the extremities of both organs. Perforation into the adjoining serous cavity is frequent, and previous to perforation collections of serous fluid are frequently noted—in the one instance pleurisy, in the other hydrarthrosis. Moreover, these fluids quickly or often become contaminated, and then become purulent, constituting empyema or pyarthrosis as the condition may be. One sees, too, in each place the same striking combinations of weakening of tissue and strengthening in order to atone for the undermining of the disease. These are not all of the similarities that might be adduced, but are perhaps sufficient for the purpose of showing that tubercular disease is essentially one and the same thing, no matter what tissue be invaded.

In the tendon-sheaths and bursæ we frequently find manifestations of tuberculosis. When seen early these are always in the direction either of miliary affection or, most commonly, of tuberculous gumma, while when seen late the disease has usually advanced to the point of suppuration, and we now have cold abscess of the affected parts.

Fig. 57.



Section through shoulder of a tuberculous animal: *e*, thickened capsule; *g*, caseous focus; *h*, miliary tubercles (Krause).

In many joints and tendon-sheaths, particularly the latter, we find certain detached, usually colorless, firmly resistant masses, of smooth and polished surface, lying in a collection of fluid, in size from a minute particle up to that of a melon-seed. These have been known at various times as *rice-grains*, *melon-seed bodies*, *corpora oryzoïdea*, etc., and for a long time their explanation was a mystery. It is now well established that in the majority of instances at least these are the result of fungous granulations which have become detached in small pieces, which then, in the absence of infection, have shrunken and become rounded and polished by attrition. The bursal enlargement and distention with fluid in which they are usually found is commonly spoken of as *hygroma* of that particular bursa. Tuberculosis of these bursæ, however, does not always result so harmlessly as the formation of these bodies, but, on the contrary, tubercular infiltration may extend beyond the serous limits to the surrounding soft parts, with a tendency finally to

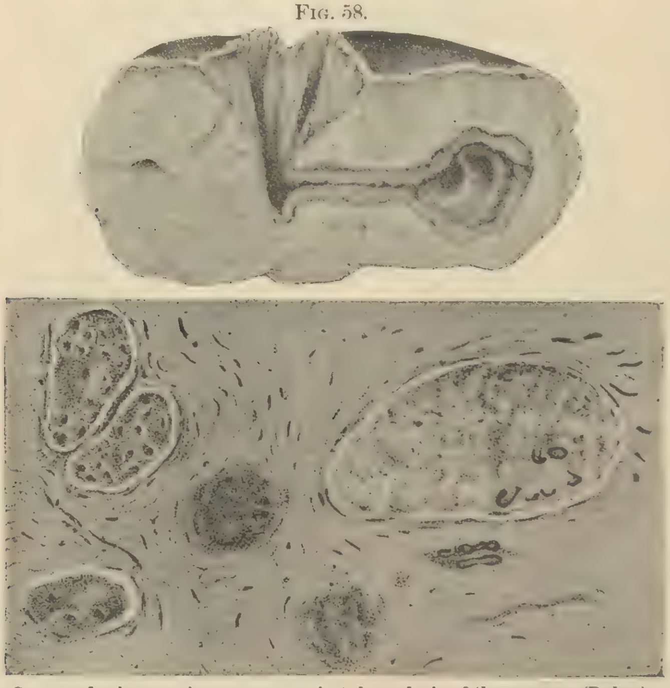
external escape, just as in the case of bone-lesions. These constitute affections of the soft parts which are more or less destructive, and are always difficult, often impossible, to deal with, because of the mutilation which a thorough extirpation of the disease would necessitate.

In the testicles and ovaries, particularly in the former, tubercular disease is frequently met with. In the testicles it begins usually in the *epididymis*, forming a somewhat dense nodule and a distinct tumor, easily appreciated from the outside, although its minute character may be still concealed. The tendency here almost invariably is to progressive infiltration and breaking down, either into a caseous mass or, more commonly, into puruloid material, while sometimes acute infection supervenes.

It is not always easy to distinguish between syphilis and tuberculosis of the testicle, though the latter is usually characterized by the same tendency to effusion into the adjoining serous cavity (*i. e.* that of the tunica vaginalis) as is manifested in disease of the lungs or bones. When the disease is extensive the overlying skin is involved, and frequently by the time the surgeon has to deal with these cases perforation and escape of fungoid tissue on the outside have occurred.

In the kidneys, in the ureters, as also in the bladder, tubercular lesions are noted, the miliary form being particularly frequent in the former. Tubercular disease of the kidney leads sooner or later to casea-

FIG. 58.



Gross and microscopic appearances in tuberculosis of the mamma (Dubar).

tion and a condition of pyonephrosis or its equivalent, which calls practically always for extirpation of the affected organ. Tubercle bacilli are sometimes recognized in the urine, but only when the lesion has an opportunity of discharging into one of the urinary passages.

In the peritoneum tubercle appears usually in the miliary form, leading sometimes quite rapidly to such extensive involvement of, and interference with, visceral functions as to produce *anasarca* or more general disturbance prior to death. Acute miliary disease here is as rapid and as essentially fatal as the same affection of the dura or pia, while the more chronic forms are followed by degenerations that may involve the intestines either in agglutinated masses or in ulcerations and possible perforations. The indication in all tubercular lesions of serous membranes is for exposure by operation, disinfection of the surface, and evacuation of retained fluids. Recovery from tubercular peritonitis, even of acute type, after abdominal section is now definitely established as a possibility. The same would probably be true of tubercular meningitis were we permitted to expose the membranes and attack them or drain them in the same way.

Although a few distinct organs or tissues have here been specifically considered in their relations to tubercular disease, there is no organ nor tissue in the body which is exempt from its ravages and in which evidences of tubercular disease may not be found. Even the *mammary gland* occasionally presents tumors composed of tubercular granuloma which more or less simulate malignant disease, while, nevertheless, calling for the same radical treatment. (Vide Fig. 58.)

Paths of Infection.—The tubercular virus may enter the body through various channels. Probably in the majority of instances it gains entrance through the *respiratory tract*, less often by the *alimentary canal*, and *occasionally by air-contact of open wounds or direct infection by local agencies.* It is now well established that tubercular disease is not inherited, although a predisposition to its ravages certainly is transmitted from parents to children.

In what this predisposition consists is not always easy to say. As the tubercle bacillus grows in the tissues, it is by preference an anaërobe, and it seems to be lowered in activity or banished by access of oxygen. It has been shown that in those individuals in whose pallid skin, long bones, flabby muscles, and pale conjunctivæ we recognize a predisposition to this disease, the heart is disproportionately small as compared with the weight and size of the lungs. This means a relatively feeble pumping-power, and is perhaps the best explanation yet offered for what is everywhere accepted as a fact. The *mucous membranes of the nose* and *throat* are the first lodging-places usually for germs carried by the air, these finding here the warmth and moisture necessary for their detention, development, and growth. So long as these membranes be unbroken and healthy, infection is rarely possible, but let tubercle bacilli become caught in the crypts of the tonsils or the adenoid tissue in the nasopharynx, and the other disturbance, set up by irritant organisms of various species, will usually bring about conditions favoring their growth and incorporation into the living tissues. This lymphadenoid tissue, then, is as often as any the port of entry for these organisms. The explanation for local and surgical tuberculosis in bones and other accessible tissues probably is connected with causes determining at these points an area of least resistance in which the germs find tissues more susceptible than elsewhere, and in which they may live and thrive.

Not the least interesting and important of the considerations regarding tubercular disease is the possibility of an *acute outbreak of tuberculosis after long latent or chronic manifestations of the disease.* This means, in effect, the onset of *general miliary tuberculosis* which shall quickly terminate fatally, and death is not the infrequent result of such extremely rapid outbreaks from tubercular disease of joints, bones,

ovaries, etc. For the disease when it has assumed this extremely rapid type there is, so far as we yet know, no help.

That tubercular infection may follow slight abrasions and wounds is a matter of grave importance for the surgeon, since a wound made for an entirely different purpose may become infected and require a second operation for relief of the specific infection produced in this way. Thus, I have seen tubercular infection of a recently resected elbow, operation being made for compound fracture, in which the infection seemed to follow closely upon confinement in quarters inhabited by consumptives and presumably thoroughly infected with tubercle bacilli. Such experiences as these may be duplicated or many times repeated in the practice of most busy surgeons.

Diagnosis.—So far as the general recognition of tubercular disease is concerned, it is not often difficult. It is accompanied usually by more or less marked cachexia (at least this is the case when infection is serious and widespread), one of whose principal characteristics is the so-called *hectic* (habitual) fever of old writers. This was a fever of a remittent type, accompanied also by more or less colliquative night-sweats, with dryness of the skin during the daytime, flushing of the face, etc. Hectic fever, as a matter of fact, often accompanies tubercular disease, but is seldom met with until pyogenic infection has occurred and suppuration is taking or has taken place. There is now much reason to consider hectic fever as an auto-intoxication from absorption of morbid products. In advanced cases we may find evidence of *amyloid* changes, although these are seldom recognized prior to autopsy. Tuberculosis of the *skin* is distinguished from most other affections in that, while the disease advances around the margin, it tends to cicatrization in the centre of the old lesion. (See Diagnosis of Malignant Growths.) Tubercular infection and degeneration of *lymph-nodes* are usually easy of diagnosis, because there is practically no other disease which produces this type of enlargement with the accompanying cellulitis and infiltration. In fact, the other principal conditions which produce lymphatic enlargement are septic disturbance, in which it is acute; syphilis and Hodgkin's disease, in which it is generalized; and malignant disease, in which distinct evidence of the primary infection is found on the distal side of the involved lymphatics. In *bones* and *joints* tubercular disease usually makes itself known by posture-deformities, which are themselves due to muscle-atrophy and muscle-spasm—the two together being characteristic—the tendency being toward subluxations or sometimes complete displacement, the expansion of the joint-ends, the atrophy of the parts above and below, and the nocturnal and osteocopic character of the pains (starting pains). All *caries* and most *necrosis* of bone not due to the poison of syphilis and not distinctly of traumatic origin are to be accepted as evidences of tuberculosis, at least in general practice. Altogether, it is seldom difficult to recognize tubercular disease except when at a considerable depth. Here, so long as there be no suppuration, there is little tendency to *leucocytosis*, by which diagnosis as between *sarcoma* and *tubercular* infection may perhaps be made. Sometimes when in doubt the exploring trocar or an exploratory incision may be resorted to, it being always best to be prepared at the same time to proceed with whatever further operative procedure the findings may indicate.

TREATMENT.—It is well to emphasize, first of all, that *tubercular disease when circumscribed and accessible is a distinctly curable affection.* If this be once accepted, it puts a much more hopeful aspect upon the condition than it formerly bore. It moreover justifies operations of a much more radical nature than were formerly practised. Treatment should be divided into the hygienic and constitutional and the local and operative.

Of all the natural remedies, *oxygen* undoubtedly ranks first. This means the best of *ventilation*, an outdoor life if possible, and preferably in localities and at altitudes free from dust and well supplied with ozone. When this is impossible inhalations of dilute oxygen are capable of doing much good. The diet should be rich and nutritious, at the same time capable of complete digestion. The emunctories should be stimulated and elimination favored in every possible way. Undoubtedly the old standard remedies—cod-liver oil, compound syrup of hypophosphites, *et al.*—are beneficial, and much good may be accomplished by their proper use.

Certain remedies have been at various times supposed to be endowed with specific properties, and for many years clinicians have endeavored to find that substance with which the system could be safely saturated which should yet prove inimical to the parasite causing this disease. Such agent has not yet been discovered; nevertheless, much has been done in this direction. Of the remedies which to-day are lauded for this purpose, I will speak of two—namely, *creosote* and *guaiacol.* These are somewhat difficult of administration, but if the latter be given in the form of the carbonate, generally known as *benzosol*, it comes the nearest in my estimation to the ideal for which we are striving that has yet been discovered. *Benzosol* should be given to the adult in doses of at least a gram a day, perhaps more. It is much better tolerated and much less offensive than the guaiacol from which it is made. I have never seen anything but benefit result from its use, and yet would not laud it as by any means a positive cure. Nevertheless, in conjunction with other local and constitutional measures its administration may be followed by complete recovery.

Of the various *local measures*, I would place first of all *physiological rest*, which can be achieved in some places better than in others. The various forms of apparatus resorted to by orthopædists are simply mechanical measures in furtherance of this purpose. A number of surgeons have much faith in *iodoform*, used locally in solution or suspension in some menstruum like glycerin, oil, etc. The benefit which has been claimed in some cases is certainly not duplicated in the experience of all surgeons; nevertheless, it has undoubtedly been of service. A recent and most promising method of treating tubercular disease of the extremities has been suggested by Bier, and consists in the establishment of a *permanent hyperæmia* by the application of a rubber tourniquet on the proximal side of the lesion.

It would appear that the access of more blood which is thus permitted is inimical, presumably by the presence of the oxygen which it brings, to the development of the disease-germ. The method depends for its rationale upon the fact that the congested lung does not become tubercular. Lannelongue has suggested what he calls the *sclerogenic treatment* of tubercular lesions, by injection of a very dilute solution of zinc chloride, which serves as an irritant and produces a tissue-sclerosis that serves the purpose of a pyophylactic membrane, while at the same time the

solution is fatal to those germs with which it comes in contact. This treatment is painful and has not found wide acceptance.

The astute surgeon, who gains the confidence of his patients and retains it, will not hesitate to remove by a suitable operation that tubercular focus which he feels confident that he can reach and extirpate. The resulting tissue-defects may be in many instances atoned for by plastic operations. At other times this procedure means *excision of some joint*, which leaves usually a much better functionating member than would the disease if permitted to go on to spontaneous recovery—*i. e.* ankylosis—and at the same time removes a focus of disease which is a menace, if left, to the future welfare of the patient. It may mean at other times *amputation*, but the artificial limb-maker now supplies a member vastly more useful than a natural one crippled by this infectious disease. In a general way, then, time may be saved and recovery ensured by early and judicious operation, while later in the course of this protean malady it may be absolutely necessitated in the endeavor to save life. How much better, then, to operate early when less is required and when the future outlook is so good!

After operations where clean extirpation and reunion of the parts with primary healing is impossible, I recommend a local dressing of balsam of Peru containing 10 per cent. of guaiacol and 5 per cent. of iodoform. Gauze saturated with this and packed into the cavity best accomplishes the purposes of a surgical dressing for such cases.

Deep pain of tubercular lesions, especially in bone, is often relieved by *ignipuncture*, meaning thereby a perforation into the depth even of the bone-marrow by the actual cautery (Paquelin's), which may be thrust directly through the skin or which may be used after exposing the bone by incision. The use of the actual cautery, by the way, is indicated in eradicating and destroying tubercular tissue when a neat dissection or extirpation is impossible.

Tuberculin.—Finally, the treatment of tuberculosis cannot be dismissed without a reference to the glycerin extract made from a filtered culture of the tubercle bacillus, containing the peculiar toxalbumen first prepared by Koch, for ever associated with his name, and first given to the world in 1890, when its announcement created a perfect furore and aroused hopes that have never yet been, perhaps never may be, completely realized. Yet, in spite of disappointments which have often followed its use, I wish to state here my own convictions that it is a remedy of great value when judiciously used in selected cases. I have never faltered in moderate confidence in its efficiency, and have not ceased to use it since it was first introduced. To-day I believe that in almost any case of surgical tuberculosis, when properly used, it is capable of doing great good, but I would by no means rely upon it alone, but would use it as an adjuvant in the after-treatment of operative cases or as a remedy of prime importance in certain cases not adapted to operation. One should begin its use by doses of 1 milligramme, injected beneath the skin near the lesion two or three times a week, depending upon the reaction produced, increasing the dose gradually until even a decigramme may be given at once without undue reaction. The diagnostic value of the material must also not be forgotten, since by its use one may possibly decide in mooted cases as between tubercular or some other disease. Of the modifications of this remedy introduced by Klebs, Hunter, and others there is not time here to speak in detail. Undoubtedly they all have virtues of a common character, and, so far as my own observation is concerned, one has but little to choose as between them.

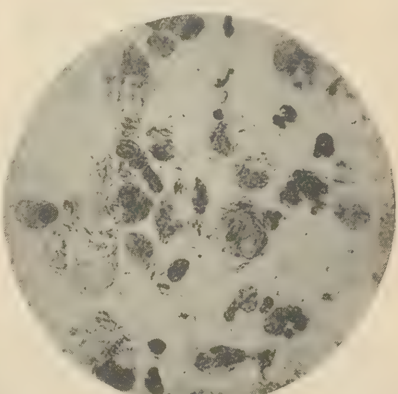
APPENDIX TO CHAPTER IX.

LEPROSY.

THIS is known also as **lepra** and **elephantiasis Græcorum.** It is an infectious disease, in many respects resembling tuberculosis (hence included in this chapter), rarely presenting any acute phases, however, and met with in the United States only among foreigners, and, save in a few restricted localities, but very rarely. In ancient and sacred history the disease figures very extensively, and would appear to be dying out rather than gaining ground. I was assured, for instance, by the director of the Lepers' Hospital, in Jerusalem, in 1894, that there were only about 60 cases of leprosy remaining in all Palestine, and that the disease might easily be stamped out did the government exercise the slightest precaution or take the slightest interest in so doing.

To Hansen and Neisser we owe the recognition of the *Bacillus lepræ*, the parasitic agent which produces leprosy. It closely resembles tubercle bacilli, except that it is somewhat shorter. It is non-motile—divides mostly by fission, perhaps also by spores. These bacilli are found in the *granulomata* produced by this disease, which new formations occur especially in the *skin*, in the *nerves*, the *lymph-nodes*, and in the *viscera*. These bacilli appear to lie preferably in the lymph-spaces of the tissues, but are often found enclosed within giant and other cells. The disease is apparently incapable of transmission to animals. Inoculation upon criminals condemned to death has succeeded. Leprosy, being due to a *contagium vivum*, is not only an infectious disease, but appears to be communicated by contagion or at least by cohabitation. Transmission by inheritance is not proven.

FIG. 59.



Bacilli of leprosy, from the juice of a leprous nodule ; × 1000 (Fränkel and Pfeiffer).

SYMPTOMS.—Two types of leprosy are described by all writers—the *anæsthetic* and the *tubercular*, the latter referring to gross appearances, not to its specific nature. Leprosy of the *skin* is marked first by hyperæmic areas which become pigmented and thickened and form, finally, brownish-red nodes the size of a robin's egg or larger. These develop most rapidly upon the face, either singly, or in numbers which finally coalesce, with great physical deformity as the result, and the peculiar appearances which have been given the name of *elephantiasis Græcorum*. It has sometimes been (falsely) spoken of even as *leontiasis*. These nodes consist of granulation-tissue, which by itself is not dissimilar from that produced by any other of the surgical diseases characterized by granuloma.

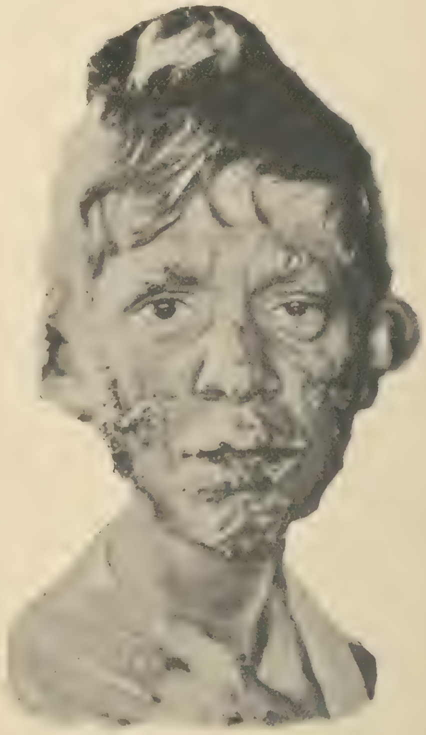
When the *nerves* become involved the disease begins with hyperæsthesia and pain, followed later by anæsthesia and trophoneurotic disturb-

ances of nutrition; as the result of which ulcerations or dry necroses occur in the extremities, which are gradually lost in this way. Thus it is a common thing to lose the fingers and toes, while the loss of a hand or foot is not uncommon. I have seen one patient, in Jerusalem, whose fingers had become thus affected, one after another, and who had himself bitten them off as they became useless, so that each hand showed

FIG. 60.

Leprosy (kindness of Dr. Craig).

FIG. 61.



Leprosy (kindness of Dr. Winfield, Brooklyn).

the loss of all five digits. Later, the disease affects the lymphatics, the mucous membranes, then the larynx, liver, spleen, testicles, etc., with progressive loss of function of each. Joints which are involved in leprous disease bear a strong resemblance to those affected by the tumor albus of tuberculosis, in some instances the pain complained of being very great.

PROGNOSIS.—The disease is curable when taken early and rigorously treated. This is possible, however, or at least practicable, in so small a percentage of cases that ordinarily the prognosis appears very unfavorable. Patients rarely die in less than one year, and often live as many as twenty years before finally succumbing to the lesions of the disease.

Treatment.—In the way of treatment there need be but little said here. All the local lesions which can be attacked should be treated radically, as in the case of tuberculosis. Chaulmoogra oil has been vaunted as a remedy of great value, but the specific cure for the disease has not yet been discovered. So far as concerns the present purpose of this article, the treatment is practically surgical and operative.

CHAPTER X.

SYPHILIS.

BY J. A. FORDYCE, M. D.

SYNONYMS.—Lues venerea; Morbus gallicus; Pox; Verole, etc.

Syphilis is a *chronic, general infectious disease, acquired by direct contact with a lesion of the malady in another individual, through the medium of some infected object, or by inheritance.* It is generally a venereal disease, though many exceptions to this rule exist.

The infection pursues a somewhat regular though indefinite course, periods of activity alternating with periods of repose or latency. It begins with an initial sore, the point of entrance of the virus, after a period of incubation following exposure. In inherited syphilis no primary sore is present. The initial lesion is followed by a second period of incubation, during which time a slow, general infection of the body is taking place, characterized by lymphatic node-enlargement, pains in the joints and bones, usually worse at night, anæmia, fever, loss of strength, and by other symptoms indicating a progressive intoxication of the organism.

Syphilis presents many points of similarity in its symptomatology and morbid anatomy to the chronic infective granulomata with which it is usually classed. In many of them the virus retains its activity for long periods of time, and in certain stages produces lesions which are local rather than general. Attention has also been called to the resemblance which exists between syphilis and the acute exanthemata, in that a definite period of incubation in all these diseases is followed by symptoms of general infection, with an outbreak on the skin and mucous membranes and transitory congestions of various organs and tissues. The acute eruptive fevers and syphilis are alike in conferring a partial or complete immunity against subsequent attacks, and it is a noteworthy fact that the essential nature of the contagion of these affections has eluded our investigations.

Although in some of its manifestations syphilis may be compared to the acute exanthemata, it is essentially different in having a fixed virus, in its protracted course, and in the multiplicity of its symptoms. After tuberculosis, syphilis is probably responsible for a greater variety of morbid processes than any other disease. The gummatous deposits, interstitial growth of connective tissue, and vascular changes which take place in the later periods of the affection are responsible for many of the chronic pathological changes which appeal for diagnosis and treatment to both the physician and surgeon. Syphilis of the bones and joints, testes, and of other organs has been wrongly treated for tuberculosis, while amputation of the tongue has been performed for gumma under the mistaken diagnosis of epithelioma.

The cutaneous lesions of syphilis often present many features in common with lupus and leprosy, as well as with the more usual and less serious dermatoses.

Stages of Syphilis.—Although not separated by well-defined limits, it is generally customary to divide syphilis into three stages or periods, which may be briefly defined as follows:

Primary syphilis embraces that period of the disease which elapses from the moment of infection to the appearance of general symptoms, including the *first incubation*, the time from exposure to the appearance of the initial sore, as well as the *second period of incubation*, the time following the primary lesion to the appearance on the skin of the characteristic exanthem. The first stage of syphilis, while varying in duration from eight weeks to four or five months, is pretty regular in its evolution.

The secondary stage, or secondary syphilis, includes for convenience of study and classification the early eruption on the skin and mucous membranes, as well as the accompanying disturbance of the general health and other phenomena which are peculiar to the time in question. One type of eruption may be rapidly succeeded by another, or intervals of latency may occur between the successive outbreaks of the disease for a period of from one to three years, or longer, before the development of lesions which belong to the so-called **tertiary stage.** This period of syphilis, which is of exceptional occurrence and multiform in its manifestations, is spoken of as the *stage of gummatous formation*, and includes the deeper-seated and destructive lesions of the skin and underlying tissues, visceral and bone affections, as well as other pathological changes which are directly or indirectly due to the specific virus.

The *early eruptions* are usually *superficial*, of symmetrical distribution, rapid in their development and course, while the later ones occur without order, are slower in their evolution, and show a greater tendency to undergo degenerative processes with destruction of the implicated tissues.

In *primary and secondary syphilis the disease can be conveyed by inoculation and heredity*, while *in the later stages it is exceptional* for such transmission to take place.

In whatever way syphilis manifests itself, the process is of an inflammatory nature, both in the initial lesion, the transitory eruptions on the skin, to the formation of gummy tumors and interstitial connective-tissue growth in the late stages of the disease. The implication of the blood-vessels in the inflammatory process, leading to thickening of their coats and partial or complete obliteration of their calibre, plays an important rôle in the pathology of the syphilitic disease and its results. This blood-vessel inflammation is found in the initial lesion, the secondary eruptions, in gummatous tumors, and in connection with the chronic connective-tissue hyperplasia resulting directly from the irritant action of the specific virus or which occurs in organs which are or have been the seat of syphilitic new growths.

The tendency which specific lesions have to undergo absorption or necrosis is explained in part by the peculiar nature of the virus, as well as by their lack of nutrition caused by the narrowing or obliteration of their nutritive blood-vessels. The gummy tumor, which is looked upon as the type of the late syphilitic products, is a granulation-tissue growth which frequently develops at the site of the chancre or of earlier eruptions as the result of irritation, seeming to show that the virus has remained in a latent condition in certain localities. It may occur as a single, sharply-defined tumor, surrounded by condensed connective tissue, as multiple pinhead-sized or larger tumors, or as a diffuse infiltration. In color gummata are grayish-white when situated in the viscera or subcutaneous tissue, and are seldom painful except when in the periosteum or the meninges. The cells compos-

ing them are small round cells, with occasionally giant cells. According to Unna, the cell-mass is made up principally of plasma-cells. These cells gradually degenerate into a central mass of yellowish-white, cheesy-looking material which may be absorbed, or into a semifluid mucilaginous substance which gives the name "gummy tumor" to the new growth. The investigations of Neumann and Unna have shown that, after the disappearance of the initial lesion and the secondary accidents, microscopic evidences of pathological conditions remain as a cell-infiltration about the vessels. It is quite probable that the localization of the late lesions of the disease is determined by such remains of the morbid process.

Etiology.—Most of the chronic infective granulomata have been shown to depend on the presence of specific micro-organisms. As syphilis presents so many features in common with these affections, it is rational to suppose that it depends on a similar cause. The infectious character of the disease, its period of incubation, its gradual implication of the lymphatic system, the blood, and all the tissues of the body, clearly point to some infectious agent which multiplies in the system, and either directly or by virtue of its chemical products evokes the tissue-reaction and a general condition which constitute the morbid process.

The facts that the lower animals are immune to syphilis and that cultivations from the infectious lesions yield no uniform or satisfactory results, render the study of its etiology one of great difficulty. The claims made regarding the presence of micro-organisms in syphilitic lesions before modern bacteriological methods came into use are without value. In 1884, Lustgarten[1] claimed, by a special method of staining, to have found bacilli in the initial lesion, secondary papules, and in gummata, which closely resembled tubercle bacilli, but were thought to differ from the latter in their staining reaction. It has since been found that the tubercle bacilli cannot well be differentiated from the so-called syphilis bacilli by the method in question.

The presence of micro-organisms in syphilitic lesions has been confirmed by Doutrelepont, De Giacomi, Gottstein, Matterstock, and many others, while Zeissl and equally good microscopists have attained negative results only. The specific claims for the bacillus of syphilis received a severe blow from the results of Alvarez and Tavel's investigations.[2] Negative results were obtained by them in the examination of many syphilitic lesions, while bacilli were found in the smegma from the prepuce and female genitals which resembled in every respect those described by Lustgarten as peculiar to syphilis. Alvarez and Tavel's results, as regards the smegma bacilli, have since received general confirmation. Bacilli undoubtedly exist in the products of syphilis, although they are few in number and the results attained by various workers are not uniform. Their small number in such highly infectious lesions as the chancre and mucous patches speaks against their etiological relationship to the disease, unless the coloring methods are at fault. It is possible, as pointed out by Lustgarten, that the bacilli are only capable of taking up the stain during a short period of their existence. As a rule, the spores of micro-organisms take the aniline dyes with difficulty, if at all; and it is known that in certain tubercular lesions their specific nature can only be positively demonstrated by cultures and inoculation-experiments.

Although many essential conditions are wanting to establish conclusively the etiological connection of the bacillus of Lustgarten, it is still held by many competent syphilographers to bear some relationship to the disease, in spite of its close resemblance to the bacillus of smegma. The presence of bacilli in gummata would lend some support to this view, were it not that it so closely resembles the tubercle bacillus and stains in the same way. Bacilli have been found in lesions resembling gummata which were shown by inoculation-experiments to be tubercular (Sabouraud).

Secondary Infection in Syphilis.—Pyogenic cocci have been found in syphilitic skin-eruptions, the bones, liver, and lungs of children who

[1] *Wiener med. Wochenschrift*, No. 47, 1884. [2] *Archives de Phys.*, Oct., 1885.

had died with hereditary syphilis (Kassowitz and Hochsinger). Kolisko, Chotzen, and Doutrelepont made similar observations, and believed they gained entrance to the general circulation through the skin-lesions. While attributing to them no etiological importance in producing the disease, they yet thought the fatal issue in some cases of hereditary syphilis depended on septic processes brought about by such secondary infection. Their presence in the bones was believed to explain the suppuration which is here sometimes met with in children with the disease.

As the *specific lesions in acquired syphilis seldom suppurate*, many modern writers believe that the exceptional occurrence of suppuration is determined not so much by the direct action of the virus of syphilis as by a secondary or mixed infection with pyogenic germs which gain access through solutions of continuity or are incited into activity by the diminished resisting power of the diseased tissues.

The presence of *pyogenic cocci* in the deeper layers of the normal epidermis, as shown by Welch and others, renders the theory of the secondary infection of the specific lesions extremely probable. Gummata of the skin suppurate much more frequently than similar lesions of the internal organs, and pustular lesions in general are more frequent among the poorer classes of society who pay less attention to personal cleanliness. It is not improbable, however, that the agent causing syphilis may under certain conditions acquire a greater virulence, and either directly or through an increased production of toxines give rise to suppurative lesions. Unna[1] believes, as the result of his own investigations, that mixed infection with pus-cocci is of very exceptional occurrence. One would infer from his statements that the virus of syphilis is in itself responsible for most of the pustular eruptions of the disease.

Campana[2] and his pupils have by means of cultures and inoculation-experiments shown that suppuration in many such eruptions depends on the presence of the staphylococcus aureus and albus, and Lang,[3] in a case of a malignant pustular syphilide, found the staphylococcus albus in the tissues at a distance from the lesions.

The *character of the syphilides is altered by other forms of mixed infection*, notably by a combination about the face and scalp with the seborrhœal eczema of Unna. Finger,[4] in a very interesting and suggestive article, was the first syphilographer who endeavored to classify the symptoms which might be produced by the virus directly and those which presumably depended on its toxic product. The initial sore, as well as the lymph-node enlargement, he considers due to both the specific germ and its ptomaïne. The latter, absorbed into the general circulation from an early date, confers the immunity which syphilitics present from an early period and long before the outbreak of the general eruption. The *anæmia* and other evidences of impairment of the general health are to be referred to a *progressive intoxication* from the chemical products which are being gradually absorbed into the general circulation. The secondary eruption, containing as it does the contagious element in a concentrated form, must be due to the bacillus alone or combined with its toxine. *This hypothesis explains in a satisfactory manner the partial or complete immunity acquired by mothers who bear syphilitic children from the father with the latent disease*, and other facts, which no other theory had attempted to do.

[1] *Die Histopathologie der Hautkrankheiten*, S. 532, 1894. [2] Morgagni, April, 1894.
[3] *Pathologie und Therapie der Syphilis*, Zweite Auflage, 1895.
[4] *Archiv f. Dermat. u. Syph.*, p. 331, 1890.

PREDISPOSING CAUSES—Aside from the virulency or attenuation of the virus which must be considered in explaining the severer and milder forms of infection, the resisting power of the individual upon whom the poison is inoculated plays an important rôle in the future development of the disease. The *extremes of life*—youth and old age—all conditions which *impair the resisting power of the patient*, as tuberculosis, anæmia, malaria, alcoholism, etc., render it probable that the future course of the affection will be grave. Tuberculosis, while it renders the course of syphilis more severe, limits the free use of mercury, and thus deprives us of our most useful therapeutic agent. Syphilis sometimes renders a *latent* tuberculosis active; tubercular abscesses of the lymph-nodes not infrequently occur during secondary syphilis in individuals who were apparently in robust health before their infection. Tuberculosis of the lungs has been precipitated by the presence of syphilis.

Chronic alcoholism is an important factor in increasing the vulnerability of the tissues to the specific poison. As both alcohol and syphilis have a predilection for the blood-vessels, their combined effects result in a more serious pathological condition.

The Lesions and Secretions which Convey the Infection.—It is necessary for the syphilitic virus to come in *direct contact* with an abrasion of the skin or mucous membrane to convey the disease. This may occur directly or through the medium of some infected object. The initial lesion and all the early eruptions have been proven to be virulent by many observations, as well as by experimental inoculations. The secretion from *condylomata lata*, which are so frequently found on the female genitals, are believed by many to be the most frequent source of infection. Successful inoculations with the *blood* of patients during the early eruptive period have been made. It is not definitely established how long the blood retains its infective properties, but in the opinion of Finger and others it does not contain the virus during the latent stages of the disease—in the intervals between the periods of the eruptions.

It is generally believed that the *physiological secretions*, milk, saliva, perspiration, tears, and urine from syphilitic subjects do not contain the virus or in such a diluted form that infection from them is not possible. As the micro-organisms of certain infectious diseases may pass through the glandular epithelium and appear in the saliva, milk, urine, etc., the possibility of transmitting the disease by such secretions is not absolutely excluded. The *semen* from syphilitic individuals cannot give rise to the disease by inoculation. The hereditary transmission of the disease from the father to the child without a previous infection of the mother is well established. The *infection of the ovum* by the diseased spermatozoön is accomplished by a *different process* from experimental inoculation. The mother may convey the disease to her child through an infected ovum, the father being healthy. It is generally conceded that pathological *secretions not properly belonging to syphilis* are *not infectious unless* mixed with the patient's blood or disintegrated portions of specific lesions.

Gonorrhœa or *chancroid may be contracted* from a patient with syphilis, and yet *no constitutional infection follow.* When *vaccinal lymph* is taken from a syphilitic subject, syphilis will not be conveyed unless

there is an admixture of blood. Experimental inoculation made with the secretions of tertiary lesions have given negative results only. These results coincide with our every-day experience, which teaches us that the late lesions are, as a rule, neither inoculable nor transmitted by inheritance, and that such persons may be reinfected. As at one time the innocence of the secondary lesions of syphilis was affirmed, a wider experience may modify our view regarding the infectious character of the later ones.

MODES OF INFECTION.—The delicate mucous membrane of the genital organs is easily abraded during sexual intercourse, and the absorption of the virus is thus facilitated. It is not difficult, therefore, to understand that over 90 per cent. of all primary sores occur on the genitals. In *man* the *chancre is* most frequently found on the inner side of the *prepuce*, its free edge, the *glans*, or *sulcus coronarius*. It is also met with on the skin of the penis, the scrotum, in the urethra, on the perineum, about the anus, etc. In *women* the *labia*, the tissues about the *clitoris* and *urethra*, and the *fourchette* are frequently its seat. It is found less often on the vaginal walls and the os uteri. Chancres on extragenital parts, as the lips, the tongue, the tonsils, the eyelids, and nipples, are not infrequently met with as the result of unnatural practices. Chancres of the lips are found in 3 per cent. of all cases, many being acquired in an innocent manner. *Wet-nurses* are infected on the nipples by syphilitic children, multiple chancres sometimes resulting; children, too, are infected by wet-nurses with lesions on the nipples. Chancres on the face and fingers sometimes follow *bites*. *Surgeons* may acquire the disease on cuts or lesions of the hands when operating on patients with active syphilis. *Accoucheurs* and *gynecologists* are sometimes infected on the fingers in vaginal examinations. Infants may be inoculated during parturition. These modes of infection are by *direct contact.*

Mediate Contact.—The syphilitic poison may be conveyed by drinking vessels, eating utensils, or any articles used in common by members of a family or by individuals. In certain occupations, as where an implement like the blowpipe in glass-factories is passed from one person to another, infection has been produced. The disease has also been conveyed by surgeons' instruments, dentists' instruments, etc.

Vaccinal syphilis is now seldom encountered, as "humanized lymph" is not often employed. Syphilis may, however, be conveyed during vaccination by the use of an infected instrument.

The disease when acquired in an innocent—*i. e.* non-venereal way—is often spoken of as *syphilis insontium.*

THE CHANCRE.

SYNONYMS.—**Initial lesion; Primary sore; Syphilitic chancre; Initial or Primary sclerosis; the Hard or Infecting chancre; Hunterian chancre, etc.**

The *interval* that elapses from exposure to the syphilitic virus to the appearance of the primary sore, or chancre, is called the *first incubation-period.* Experimental inoculation made on healthy persons showed that the minimum duration of this period was *ten* days; the maximum, *forty-*

two days; its most frequent duration, *from three to four weeks.* After accidental inoculation clinical observation has shown the mean duration to be about *three weeks.* It may exceptionally last seventy days or longer.

Every case of syphilis, with the exception of the hereditary form, or syphilis conveyed from the infected fœtus to the mother, begins with a primary lesion. It may be so slight and heal so rapidly as to escape observation, or in such a locality as not to be readily found. It must, however, have been present. It is seldom that an absolutely typical sore in its early stages comes under the observation of the surgeon. It is frequently complicated with other infections or its appearance has been changed by caustic applications. The classical sign, *induration*, may be wanting from a primary lesion which is followed by the constitutional disease, or it may exist in a purely local sore. Errors in diagnosis are of frequent occurrence from placing too much diagnostic importance on a single feature. A typical chancroid may be converted into an indurated initial lesion, and instances of well-defined indurated sores have been observed without any constitutional disturbance.

The *initial lesion* is usually *single*, unless several abraded spots are inoculated at the same time, or other eruptions, like herpes or the lesions of itch, are present where infection takes place. It is not at all unusual to see two or three chancres at the same time, and as many as a dozen have been observed to develop simultaneously. Immunity to subsequent infection seems to take place very soon after a successful inoculation, although it is possible for a second infection to occur within a short time after the original one.

Induration.—This one sign is *almost pathognomonic of the chancre.* It is present to some extent in the vast majority of cases. When well developed it extends beyond and beneath the limits of the superficial erosion or ulceration, and feels, when grasped between the thumb and fingers, like a piece of cartilage imbedded in the skin. Its firm and elastic consistency serves to distinguish it from other inflammatory infiltrations, while its boundaries are much better defined than in the chancroid. The superficial variety gives to the finger the sensation of feeling a thin piece of cardboard or parchment beneath or in the skin.

The characteristic induration met with in the initial sore is found only in two other conditions—rhinoscleroma and scleroderma. It is thought by Unna to depend principally on hypertrophy of the gelatinous connective-tissue substance, and secondarily on the cell-infiltration present at the same time. The cell-infiltration is found in the early stages of the chancre before induration is at all marked, and also in many other conditions without such induration, so that its presence alone does not account for the peculiar hardness of the new growth.

The development of the uncomplicated initial lesion is, as a rule, *unattended by any subjective sensations*, and frequently its possessor is ignorant of its existence. The ulceration or abrasion rapidly heals, but the specific induration passes away slowly and is of uncertain duration. It sometimes disappears within a few weeks after the secondary eruption, or in exceptional cases may last for six months or a year. It generally leaves no trace of its existence, but may terminate in a superficial pigmented or pigmentless scar or spot or a keloid-like induration which gradually disappears.

Varieties of Chancre.—After experimental inoculation on parts of the cutaneous surface removed from sources of irritation or infection

FIG. 1.

Ulcerating Initial Lesions. In one sore the healing process is more advanced.

FIG. 2.

An Ulcerating Initial Lesion, showing central gangrene. Secondary eruption present at the same time.

FIG. 3.

Chancre of the Lip.

it assumes the appearance of a *dry scaling papule.* A small patch of round or oval redness marks its beginning: this soon becomes more prominent and infiltrated, developing into a pea or bean-sized nodule, over which the epidermis may be slightly thickened. An abrasion may develop over the centre of the papule, giving exit to a serous discharge which dries as a thin crust. The papule may slowly disappear without ulceration, or become more infiltrated at the base and present a superficial ulcerated surface surrounded by a slightly elevated margin. The ulceration in this, as well as in other varieties of the initial lesion, takes place at the expense of the cell-infiltration rather than of the normal elements of the skin, being apparent rather than real, and healing without loss of the connective tissue of the derma.

The Superficial Erosion.—This is the primitive lesion in the vast majority of chancres which are not preceded by the soft sore. When seen sufficiently early, it appears as a rounded, sharply-defined spot, of a dark-red color, from which the superficial epithelium has been detached, exposing a moist, smooth, or slightly granular surface. There may be an insignificant central depression, but the edges of the erosion are usually on a level with the surrounding skin. One or more such lesions may exist, which gradually develop an indurated base and heal more slowly than an ordinary excoriation or abrasion. The induration may be superficial and thin, assuming the *parchment-like* form, or extend deeper, giving rise to a distinct nodule.

As the cell-infiltration in the initial lesion is in the main located about the blood-vessels, their anatomical distribution explains in part the varied outlines of the scleroses. The presence or absence of much loose connective tissue beneath the sore also moulds the outlines of the infiltration.

The Hunterian chancre, or **ulcerating initial lesion,** is the most pronounced and well-developed form of the syphilitic sore. It originates in an erosion or papule which increases slowly in size, is sharply circumscribed, of round or oval outline with a somewhat flattened top. With the increase in size its consistency becomes harder until it approximates that of cartilage. In color the new growth is brownish- or bluish-red. After a duration of ten or twelve days its epithelial covering becomes macerated, giving rise to a serous discharge, or it becomes covered with a gray film. The centre of the infiltration undergoes a process of molecular disintegration; its edges become elevated, so that an appearance of ulceration is presented which gives the impression to the observer of a greater loss of tissue than is in reality the case.

A well-marked Hunterian chancre therefore presents an infiltration or sclerosis from the size of a silver dime to that of a quarter dollar, or larger, in circumference, surmounted by an ulcer with elevated sloping edges involving an area much less than the underlying cell-growth. In Plate V. Fig. 1 two typical sores of this kind are shown, in one of which the ulceration has healed, leaving only a slight central depression; in the other the surface of the ulcer is granular and the cicatrization is beginning to form about the edges. In unfavorable conditions of health, from local infection or from obliterative endarteritis and endophlebitis, gangrene may attack the sore, causing the loss of a part or the whole of the diseased tissue (Plate V. Fig. 2). Spreading phagedena is, however, not so frequently met with as a complication of the specific sore as formerly.

After three or four weeks' duration the Hunterian chancre begins to

undergo a slow process of *involution*, which is hastened by the local and internal use of mercury. It heals without loss of tissue or with an insignificant scar.

The Mixed Sore.—The subject of chancroid is considered in another part of this work (Vol. II. Chap. XII.). It is sufficient to state here that it is a *local infectious ulcer*, with a short period of incubation, almost exclusively met with on the genital organs. Infection with the virus of chancroid and syphilis may take place at the same time, the former passing through its stages of papule, pustule, and ulceration, with free suppuration. At the end of two or three weeks, the incubation-period of the syphilitic sore, the base and edges of the chancroid assume a characteristic induration and a brown-red color; granulations spring up and the secretion of pus becomes less. Within a few days the local infectious ulcer is converted into a typical sclerosis which pursues the ordinary course of the latter. The syphilitic infection may, of course, follow that of the chancroid, but usually is simultaneous.

Induration or sclerotic œdema is looked upon by some syphilographers as a distinct variety of the initial sore; by others as a complication of one of the forms previously described. It is of rare occurrence, being generally found on the labium majus, occasionally on the mucous surface of the prepuce or the skin of the scrotum. The usual erosion or papule is not present, the only lesion being a firm and elastic swelling which gradually increases until the parts become two or three times their normal size. It is much firmer than inflammatory œdema, but less so than the induration about the initial sore. In consistency it more nearly approaches that of scleroderma. This indurative œdema passes away slowly and leaves no mark of its former existence.

COMPLICATIONS OF THE CHANCRE.—Local pyogenic infection is responsible for an extensive *ulceration or suppuration* of the primary sore. At times the inflammatory process may be so intense that the parts become much swollen and painful. When the preputial opening is narrow the occurrence of a chancre on its inner surface or in the sulcus coronarius often leads to complete *phimosis* or *paraphimosis*. The retention of the secretion from the sore in the preputial sac macerates the epithelium of the glans, producing an intense balanoposthitis, the discharge from which may simulate a gonorrhœa. Under such conditions the entire penis may become red, painful, and swollen. A neglect at this time to relieve the tension by a dorsal incision of the prepuce may result in superficial or deep gangrene, with partial or complete destruction of the glans, and possibly urethral fistulæ or other complications.

Extragenital Chancres.—Certain peculiarities are presented at times by chancres of the general integument or mucous membranes at a distance from the genital organs. A chancre at the *margin or bed of the nail* seldom shows marked induration; exuberant granulations are sometimes seen, and frequently suppuration is profuse. On the *cheek* or *chin*, where the tissues are lax, it attains a large size. It may ulcerate and be covered by crusts, and has been mistaken for malignant disease. A *tonsil* which is the seat of a chancre enlarges, generally ulcerates, and at times is covered by a pseudo-membrane simulating the diphtheritic membrane. Enlargements of the submaxillary and cervi-

cal lymph-nodes are simultaneously present. Difficult deglutition is often experienced. Chancres on the *lip* are commonly indurated, and sometimes present well-marked ulceration with a dark-red granulating surface (Plate V. Fig. 3).

Enlargement of the Communicating Lymph-vessels and Nodes.—After the appearance of the initial sore, the next manifestation of the specific infection is in the *lymph-nodes* in anatomical communication with the lesion. Exceptionally, one or more lymph-vessels or thickened veins may be felt as firm, hard, painless cords extending along the dorsum of the penis to its root. At times nodules form in the course of these thickened vessels, which undergo spontaneous involution or ulcerate.

The characteristic lymphatic involvement appears, usually, within a week after the initial lesion. In genital chancres the nodes are seen and felt along the line of Poupart's ligament, although it has been shown that the crural and iliac nodes are also involved. The enlargement may at first be more evident on the side corresponding to the lesion, but later both inguinal regions are generally similarly implicated. The nodes are painless, hard, freely movable, and not attached to the overlying skin. Several nodes on both sides are involved: they remain sharply defined, and seldom exceed the size of an almond. There is no redness of the skin or other evidence of an acute inflammatory process, unless an infection with pus-producing organisms takes place at the same time. When such is the case, a number of nodes may be matted together by the septic inflammation, miliary abscesses form in them, and a condition results which can only be satisfactorily treated by their excision.

The presence of localized lymphatic complications may sometimes be a guide in finding the initial lesion when on extragenital parts. Chancres on the body below the umbilicus, except on the os uteri, first involve the inguinal nodes; chancres on the hand, arm, and breast, the axillary ganglia. The submaxillary nodes are enlarged in chancres of the lip and chin; the subhyoid in chancres of the tongue; the preauricular in chancres of the eyelid.

Diagnosis of the Initial Lesion.—*Chancroids* are practically always found on the genitals. They are generally *multiple*, have a *short* period of *incubation*, and begin as a *pustule* or *small ulcer* surrounded by a red areola; *a pseudo-induration may result from caustic or other applications.* The floor of a chancroidal ulcer is irregular, covered by a grayish membrane; its edges are frequently undermined, and it secretes pus freely. *Chancroidal pus is auto-inoculable*, both on the genitals and general integument. A single or double bubo, with a marked tendency to suppurate, is found in about 25 per cent. of cases of chancroid. It must be borne in mind that a chancroid frequently assumes an induration as the result of a double infection, and that the initial lesion of syphilis, from local infection or irritating applications, ulcerates and secretes pus.

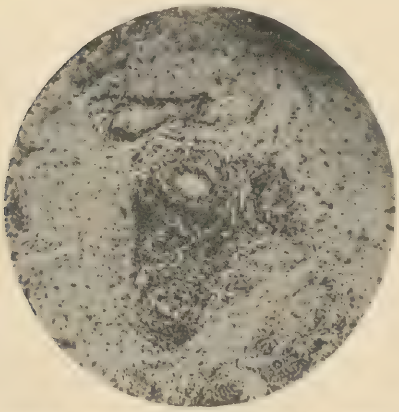
Herpes of the genitals occurs as a grouped vesicular eruption which seldom lasts longer than a few days. A history of former attacks is of aid in diagnosis. Cauterization of such lesions with carbolic or nitric acid may obscure their normal features and cause them to simulate chancres or chancroids.

A *chancre* of the lips or genitals has been mistaken for an *epithelioma*. The latter occurs later in life, is slower in its evolution, and does not implicate the lymph-nodes as soon as the initial lesion.

A late lesion of syphilis is sometimes found at the site of the original chancre, or elsewhere, which has been mistaken for a primary sore. The serpiginous extension or central ulceration, as well as the absence of the primary lymphatic involvement, would serve to distinguish it from primary syphilis.

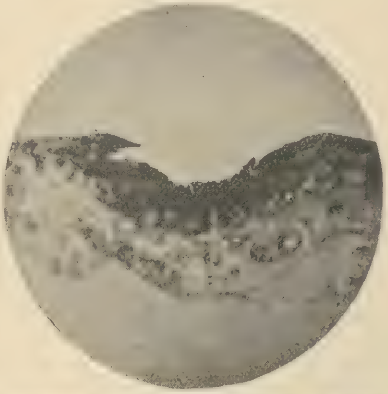
Pathological Anatomy of the Chancre.—The blood-vessels, including both the arteries and veins, show marked changes in the earliest stages of the development of the initial lesion. They are surrounded by large numbers of single, nucleated polyhedral cells, which are believed by Unna to represent proliferating connective-tissue cells ("plasma-cells") (Fig. 62). Few multinucleated leucocytes are seen. The endothelial cells of the vessels multiply, as shown by numerous mitoses and thickening of their intima; the middle and outer coats are also thickened and infiltrated by leucocytes. As a consequence of the involvement of the vessels' walls and from outside pressure their calibre is encroached upon and frequently found to be obliterated.

Fig. 62.



Showing the cell-infiltration about a blood-vessel in the chancre. The proliferation of the endothelium is also shown.

Fig. 63.



Section through a chancre under low power. Zeiss, 70 mm. No ocular.

A section through a chancre, at the height of its development, reveals a dense cell-mass in the papillary and subpapillary region of the derma, which is pretty sharply defined on all sides (Fig. 63): the blood-vessels lying for some distance outside of the infiltration are surrounded by the cells previously mentioned and present thickened walls. The epidermis at the edge of the induration in many cases is hypertrophied, the interpapillary process extending for some distance into the cutis. Leucocytes are also to be found between the cells of the epidermis, which is in part or wholly destroyed over the centre of the sclerosis. When the sclerosis is uncomplicated by a secondary infection, remains of the epidermis can frequently be seen over the central erosions, so that its complete restoration after the involution of the chancre generally takes place.

In addition to the dense inflammatory cell-infiltration about the vessels, changes in the connective tissue of the derma take place which result in its hypertrophy and a peculiar change in the gelatinous tissue-substance to which Unna refers, in part, the induration. Although there is nothing absolutely pathognomonic in the minute anatomy of the initial sclerosis, there are certain characteristics which, when found associated, will frequently enable one to make a microscopic diagnosis. These features are—the superficial character of the infiltration surmounted by a central erosion, with vestiges of the epidermis still remaining; thickening of the epidermis, with infiltration of leucocytes at the edges of the erosion; obliterating endarteritis and endophlebitis of the vessels away from the central sclerosis, together with their surrounding cell-infiltration. The involution of the chancre is hastened by the changes in the blood-vessels which limit its supply of nutrition, causing degeneration of its constituent cells, and probably by the character of the poison, which in itself may lead to necrosis of the new growth.

Prognosis of the Chancre.—It has been maintained by some writers that the future course of syphilis depends to some extent on the size or number of the initial lesion, and that an extragenital location of the chancre is apt to be followed by a severer type of the disease. *The character of the tissues on which the virus is implanted has more to do with the future evolution of the constitutional disease than the size, number, or location of the primary sores.* The most insignificant chancre may be followed by a malignant form of syphilis, while large and multiple initial sores may cause only a slight constitutional reaction.

The chancre in patients with nephritis, diabetes, tuberculosis, or other severe systemic diseases may become *gangrenous* and produce extensive local destruction of the parts. Constitutional syphilis is also apt to be a more serious disease in such patients. Under such conditions the local and general reactions are to be referred to the same cause, rather than to be considered as cause and effect. Several individuals infected from the same source react in different ways to the specific disease. In malignant types of syphilis destructive lesions are apt to be an early manifestation, anticipating their average time of development. A short duration of the periods of incubation may imply, therefore, less resisting power on the part of the tissues, and indicate a severer form of the disease, while a longer period of incubation may point to milder constitutional reaction.

Treatment of the Chancre.—In the opinion of the great majority of syphilographers at the present time *it is not possible to abort syphilis by chemical agents or the actual cautery, nor by excision of the initial lesion,* even in conjunction with removal of the inguinal ganglia.

When a chancre is situated at the preputial margin in a patient with phimosis, it may be removed by a circumcision. No hope should be entertained, however, of preventing or modifying the future course of the disease by such procedure. It is only mentioned as a hygienic measure which may, under certain circumstances, be indicated. The fact that immunity to further infection is present during the first period of incubation, before the characteristic sore has appeared, shows that some infectious matter has entered the general circulation, and that syphilis, before and at the time the chancre appears, is something more than a local disease.

Local Treatment.—The sore should be kept *clean* by the free use of soap and water. Where an erosion or superficial ulcer is present, calomel is perhaps the best application to use until the raw surface has healed. The ordinary *black wash*, a solution of bichloride of mercury (1 : 2000 or 1 : 3000), or a solution of permanganate of potassium (1 : 3000) may also be employed several times a day as local antiseptic agents.

When *gangrene* or *phagedenic ulceration* occurs as a complication, more active local medication is indicated. Compresses wet in a weak solution of chlorinated soda and kept constantly applied are an efficacious method of limiting the spread of gangrene or phagedena. The free use of iodoform is also valuable in stimulating healthy granulations after the separation of the gangrenous mass or limiting a spreading ulceration. After ulceration has healed the application of equal parts of mercurial ointment and vaseline, mercurial plaster, or ointments containing other mercurials, hastens the absorption of the induration. Its absorption is also more rapidly carried on during the internal use of mercury. Chancres on the *female genitals* should be treated in the same way, more care being here required, however, to preserve cleanliness. Chancres of the *vulva* should be freely covered with calomel and the parts kept sepa-

rated by pledgets of absorbent cotton. An initial sore at the meatus or within the urethra is difficult to treat satisfactorily. When at the *meatus* it may lead to stenosis of this orifice if the canal is not kept open by means of a small roll of lint saturated with a dilute mercurial ointment or a tampon of iodoform gauze. Deeper-seated chancres may be treated by astringent injections, combined with the liberal use of mercurial ointment externally.

If the initial lesion be in every way typical and the inguinal or other nodes present the characteristic enlargement, the *internal use of mercury is indicated even before the eruption appears on the skin.*

Chancres always gives rise to much mental distress, and when on extragenital parts, as the face, are disfiguring. They may be painful when located on the glans or prepuce in patients with phimosis. In such cases, when the diagnosis is clear, one should not hesitate to resort to mercurials internally, as the involution of the sore is thereby hastened. When, however, the character of the sore is at all *doubtful, one should await* the appearance of the secondary eruption before beginning the general treatment.

Constitutional Syphilis.

The time between the appearance of the chancre and the outbreak of an eruption on the skin and mucous membranes is called the **second incubation-period.** Its *average duration is forty-five days:* the shortest time reported is twelve days, the longest two hundred days. After experimental inoculation the shortest duration was eight to fourteen days; the longest, one hundred and fifty-nine days. During and before this time a *slow infection of the entire economy* is taking place, which may produce a serious disturbance of the general health or be of such slight intensity that the patient is unaware of any change in his condition. A *generalized hypertrophy* of the lymphatic nodes, in addition to those in direct communication with the primary sore, can be made out by the end of this second incubation-period. In some cases enlarged nodes can be detected two or three weeks before the skin-eruption appears; again, not until or after the cutaneous outbreak. The nodes along the posterior border of the sterno-cleido-mastoid muscle, other nodes about the neck, the supraclavicular, the axillary nodes, and the *epitrochlear*, are the ones which can usually be felt. In addition to those mentioned, any of the superficially located nodes may undergo hypertrophy, and the visceral nodes have been found enlarged in certain cases where autopsies have been made. The enlarged nodes vary in size from that of a bean to a pigeon's egg: they are rounded or oval in outline, painless, somewhat hard, and never suppurate unless some local condition produces a secondary infection. In tuberculous subjects previously enlarged nodes may become inflamed and even suppurate, the syphilitic virus seeming to render active the bacillus of tuberculosis, which is probably present at the same time. The duration of the enlargement is indefinite. It may pass away in a few months, a year, or some evidence of its presence may be detected after two or three years. When other causes are excluded the presence of a *generalized lymphatic involvement may be of service in diagnosticating a past syphilitic infection* after the cutaneous manifestations have disappeared. In late syphilis a gummatous or interstitial change, involving one or more nodes, has been occasionally observed.

Among the evidences of a *progressive intoxication of* the system during this period, *anæmia* is frequently met with in a greater or less degree. Stoukovenkoff's[1] investigations showed that the first blood-change consisted in a rapid increase of the number of white blood-corpuscles, a diminution in the amount of oxyhæmoglobin and in the number of red blood-corpuscles. These blood-changes were found to be more pronounced in cases where fever was present. Biegansky[2] has, in the main, confirmed these observations.

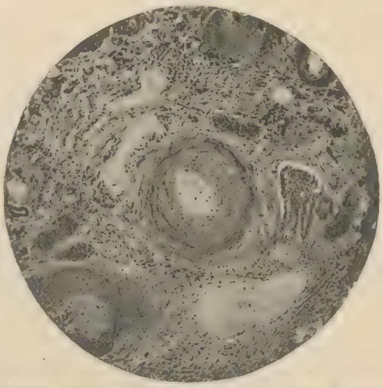
The blood-changes are more pronounced in women than in men, sometimes producing a feeble action of the heart, extreme prostration, and other accompaniments of the anæmic state. The pathological state of the blood continues in a more or less marked degree during the eruptive stage.

Fever is present in a certain percentage of cases shortly before and during the early eruptive period. The majority of patients are affected, according to the observations of some writers, while less than half show febrile reaction, according to others. As a rule, the rise of temperature occurs only in the evening, and seldom exceeds 100° or 102° F. In exceptional cases it has reached 105° F. A form of intermittent fever has been observed during the existence of late visceral or nervous syphilis.

Early syphilitic fever is a transitory manifestation, lasting, as a rule, but three or four days. It not infrequently precedes the outbreak of a pustular syphilitic eruption, and when accompanied by severe pain in the head and back the condition may closely simulate a variola.

Pains of a neuralgic or rheumatoid character are often experienced in the joints, bones, and muscles. Sometimes an effusion into one or more joints can be made out, and not infrequently a painful thickening of the periosteum, especially over the long bones or cranium, is distinctly evident. Localized or diffuse *headaches* of a severe character, with inability to sleep, or dull, ill-defined pains in the head, are often exceedingly troublesome. All the pains mentioned are intensified at night.

Fig. 64.



Endarteritis syphilitica (kidney) from a case of chronic syphilitic nephritis (× 200).

Vertigo, epileptiform attacks, hysteria, temporary paralysis of certain muscles, *analgesia* of the extremities, *increased* tendon and skin *reflexes* are among the rarer manifestations of this period. Attacks of *subacute pleurisy, enlargement of the spleen*, and *jaundice* have been noted during the secondary stage of syphilis.

In addition to *amyloid changes* and *gummatous lesions* of the kidneys, which are met with late in the disease, the occurrence of *albuminuria*, both with and without œdema, has not infrequently been observed during the outbreak of syphilitic manifestations. Early syphilitic albuminuria is generally a transient symptom, disappearing under the use of mercury and a proper diet. A severe form of *nephritis* may, however, develop, which is characterized by scanty urine containing albumen, blood-casts, a general œdema,

[1] *Ann. de Dermat. et Syphil.*, 1892, p. 928.
[2] *Arch. f. Dermat. u. Syph.*, 1892, p. 43.

and uræmic manifestations. Such severe cases may recover or develop a chronic interstitial nephritis which terminates fatally. In a case of this kind which was under my observation for several years an autopsy revealed contracted kidneys, atrophy of the glomeruli, and marked changes in the blood-vessels. A thickening of the intima, the result of a proliferative endarteritis, together with implication of the other coats, leading to an obliteration of the vessel's calibre, is shown in Fig. 64. The changes are of a similar nature to those first described by Heubner in the arteries of the central nervous system.

The *relationship of syphilis to other diseases*, and the influence which it exerts on the *healing of wounds*, are interesting questions to consider. Reference has been made to the increased gravity of the disease in tuberculous and alcoholic subjects. Bright's disease and rheumatism are aggravated when an added specific infection is present. A latent syphilis sometimes becomes active after an attack of malaria. Some observations seem to show that *fractures* occur more readily in syphilitic subjects, probably as the result of local bone disease, and that their union is at times *delayed*. Cooper relates a case where the callus which formed around a fracture of the arm was rapidly dissolved by the administration of iodide of potassium for a rupial eruption.

A specific lesion of the skin, of subcutaneous tissues, or of bone may be localized by an *injury* or chronic irritation of the parts, but wounds or surgical operations which are made during the active stage of syphilis heal as readily as on a non-syphilitic individual. A specific eruption, gumma, exostosis, or ulceration may rapidly disappear after an attack of erysipelas at the site of the lesions. A recurrence is apt to follow the disappearance of the erysipelas.

Epithelioma may occur at the site of an ulcerating gumma of the skin or mucous membrane. An intimate relationship exists between the development of *cancer of the tongue* and the peculiar change in the epithelium known as *leukoplakia*, which sometimes follows specific lesions subjected to chronic irritation.

The development of *aneurism* is closely connected with arterio-sclerosis, which, by weakening the coats of the vessels, renders them liable to dilatation after violent exertion. Although by no means the only cause of the vascular disease, syphilis is a frequent and potent factor in its production.

Syphilis of the Skin; the Syphilides; Syphiloma.

The administration of mercury during the second incubation-period, a greater resisting power on the part of the tissues, or other causes may *retard* the appearance of the specific eruption on the skin or mucous membranes. It must be borne in mind, however, that the disease is a constitutional one, with or *before* the appearance of the chancre, although at times slight evidence of its presence can be detected. In some instances the primary sore is of so doubtful a character that a diagnosis cannot with certainty be made before the appearance on the skin of the characteristic rash. As well-marked indurated chancres with inguinal lymphatic involvement have been observed that were not followed by any secondary eruptions, *it is possible for syphilis to end its existence during the primary stage.* We have no absolute proof, however, that this can occur. Many cases of syphilis are of so *benign* a character that after the appearance of an erythematous rash, which may and frequently does escape the observation of the patient, no further symptoms are ever seen. In other cases which pursue a mild course one type of

superficial eruption may rapidly follow another for a period of months or years, the general health being little impaired.

In *malignant*, *precocious*, or *galloping syphilis* destructive lesions occur early in the course of the disease, anticipating by months or years their usual date of evolution. *Gummata* appear on the skin, mucous membranes, or in the viscera, producing deformity or the permanent impairment of the functions of important organs. A profound *cachexia* results from the intensity of the infection and the accompanying lesions. The historical account of the European epidemic of syphilis in the fifteenth century shows that such forms were not so infrequent as they now are.

The cutaneous eruptions of syphilis are the most constant and characteristic manifestations of the disease: they are known as **syphilodermata** or **syphilides**, a qualifying adjective being employed to designate a special form of primary lesion or combination of lesions which is present. **Syphiloma** is a term which is sometimes used to include the late nodular or gummatous formations in the skin, mucous membranes, and viscera.

All the primary and secondary lesions which are met with in nonspecific dermatoses are also found in syphilitic ones. The latter can readily be recognized in the majority of cases by certain peculiarities of *development*, *distribution*, *involution*, *color*, *grouping*, *polymorphous character*, *absence of itching*, *etc.* Syphilis may imitate a psoriasis or lupus in its cutaneous expression, so that it is difficult to determine which affection is present. It is incorrect, however, to refer to such an eruption as a syphilitic psoriasis or syphilitic lupus, as these terms would imply a combination of the two diseases; which does not occur.

The *early syphilides* occur in a *symmetrical* manner, have a *general distribution*, are *superficially seated*, disappear spontaneously, and pursue a more rapid course than the later ones. They show a tendency to lose their symmetrical distribution after a number of months have elapsed from the time of infection. The individual lesions composing the eruption now group themselves or assume circular or gyrate outlines, indicating to the trained observer a relapsing syphilide and also the probable duration of the disease.

The first eruption, which usually appears in the form of *macules*, is often followed, before its complete involution, by a *papular*, and this by a *pustular or ulcerative*, syphilide, so that a mixed or polymorphous eruption is present.

The *color* of syphilitic lesions is due in great measure to the marked implication of the blood-vessels in the pathological process, which favors blood-stasis and exudation of the red blood-corpuscles into the tissues. The pigment which results from their disintegration in greater or less amount gives to the lesion a lighter or darker shade. At first the lesions may have a pinkish-red color which soon assumes a brownish or yellowish-red tint that has been compared to the color of raw ham or copper. A yellowish or brownish-black pigmentation may remain at the site of the lesions after their disappearance. Exceptionally, the absence of the normal skin-pigment, *leukoderma*, may mark the location of the lesions. It should be remembered that other skin affections may present equally marked pigmentary changes, and that the color of the eruption is only of diagnostic value when taken in conjunction with other features. The absence of itching, burning, or other subjective sensations in connection with the eruption is of diagnostic importance.

The later or *tertiary* cutaneous manifestations of syphilis differ from the earlier ones in their *irregular* and exceptional *occurrence*, their *localized distribution*, *deeper seat* in the tissues, *slower course*, and in their tendency to cause *loss of tissue and leave permanent cicatrices*. The central involution and peripheral extension of the infiltration is also more marked in the late syphilides. *The secondary lesions contain the virus of syphilis in an active state, while the tertiary lesions are slightly if at all virulent.* Experimental inoculation of the secretions of late syphilides has invariably given negative results.

The *specific influence of mercury* on the early eruptions, and of the *iodides* in causing the disappearance of the later ones is a remarkable instance of the selective action of drugs in different stages of the same affection. In many cases the two stages are not separated by well-defined limits, but are united by intermediate eruptions which present many of the characteristic features of both.

Roseola syphilitica, the macular or erythematous syphilide, is usually the first cutaneous manifestation of syphilis. It appears at the end of the second incubation-period as a generalized eruption of circumscribed spots of hyperæmia from the size of a split pea to that of the finger-nail. The spots are bright-red or bluish-red in color, and are not elevated above the skin-level. The eruption begins, as a rule, on the *abdomen*, then on the chest, and finally on the extremities. The face is exceptionally attacked. A week or two elapses before the eruption appears on the extremities. It may last for several days or several weeks, and usually disappears without desquamation, leaving at times light-brown pigment-spots to mark its former situation.

A *relapsing macular syphilide* sometimes occurs within the first or second year in the form of circular patches, which may reach or exceed the size of a silver quarter-dollar. This variety of the macular eruption, which has a limited and irregular distribution, is attributed by Unna to changes in the nerves supplying the affected area, similar to the nerve-changes in leprosy, which produce certain skin lesions in that disease.

The macular eruption is more than a localized hyperæmia. A cell-infiltration of slight grade is found about the blood-vessels and sweat-glands; also changes in the endothelium and adventitia of the vessels. An increase in the severity of the inflammatory process produces the syphilitic papule, which not infrequently arises from the centre of a macule, constituting the *maculo-papular syphilide*.

Diagnosis.—When considered apart from other symptoms of syphilis the *macular* eruption in its early stages may be mistaken for the eruption of another exanthem, measles, or the erythema which follows the internal use of copaiba, antipyrine, salicylate of soda, or other drugs. In its declining stage it has been confounded with pityriasis versicolor. A careful examination of the patient and a proper consideration of the concomitant symptoms serve to make the diagnosis clear.

The papular syphilide may be the first eruption or follow the macular syphilide. It occurs in the form of large or small papules, constituting the *lenticulo-papular* and the *miliary-papular eruptions*. The papular eruptions are generalized in the early months of the disease (Plate VI.); later, their distribution is circumscribed, and finally they may form transition types from the early to the later tubercular or gummatous new formations. The papule is the initial form of all the subsequent secondary lesions. It varies in size from a pin's head (the

PLATE VI.

Grouped Miliary Papular Syphilide.

PLATE VII.

Mixed Papular and Papulo-Pustular Syphilide.

miliary papule) to that of a split pea and larger (the lenticular papule). It consists of a sharply circumscribed, solid infiltration in the derma, of a light-red or brownish-red color, projecting above the level of the skin. When not the seat of secondary changes, as suppuration, it heals without scarring. In its declining stage it frequently scales, forming the *papulo-squamous syphilide,* a common form and one often mistaken for psoriasis.

On the *palms and soles* a number of scaling lesions may coalesce, giving rise to the eruption which has been *erroneously* called *syphilitic palmar and plantar psoriasis.* Annular and gyrate forms result from the central involution and peripheral extension of the lesions. The papule may be surmounted by a vesicle, bulla, or pustule, giving rise to a great variety of lesions to which distinct terms have been applied, as the *varicella-form,* the *variola-form,* the *impetigo-form,* the *ecthyma-form,* and the *acne-form* of the syphilides. It should be remembered that all these forms of eruption represent changes which take place in the papule and follow its localiza-

FIG. 65.

Grouped papulo-pustular syphilide and numerous pigmented spots from former lesions.

tion, size, and outlines, papular, pustular, and transition forms of eruption being frequently seen on the same patient (Plate VII. and Fig. 65). They do not represent essentially different lesions, but occur, as a rule, after the papule is developed from some condition of the patient or an increased virulency of the syphilitic poison.

In *cachetic* or *alcoholic* individuals, or in those whose resisting power is slight, the papule may not reach its complete development before breaking down into a pustule. In such patients the primary eruption of the disease may rapidly assume a pustular form, leaving pigmented scars after healing.

The **ecthyma-form syphilide,** or the *large pustular* variety, occurs by preference on the lower extremities or scalp as a superficial or deep affection, giving rise to large, irregularly-shaped ulcers, having a livid, grayish, or gangrenous floor which secretes a bloody pus that dries in the form of dark-brown or black crusts. Ulceration extends beneath the crusts. This type of eruption is rarely seen during the first six months. It is more usual as a late secondary or intermediate eruption. In Fig. 66 two symmetrically situated ulcers on the legs are shown which are the result of this form of the syphilide. They can be differentiated from the ulcers resulting from broken-down gummata of the subcutaneous tissue, as the latter are scarcely ever symmetrical, and have as their antecedent stage a deep-seated solid tumor, which ulcerates in the centre and affects the skin secondarily.

Rupia, or the rupial syphilide, is a form of the large *pustular erup-*

tion resulting in ulcers which are covered by concentric layers of crusts. It may occur within the first six months as a precocious eruption, as a late secondary, or as a tertiary outbreak. The papule, if it exist at all, has a very transient duration, the first lesion being a bulla or pustule.

FIG. 66.

Ulcers resulting from the deep ecthymatous syphilide.

The secretion is abundant, thick, and dries rapidly in superimposed layers of greenish-brown or blackish-brown crusts, beneath which the ulceration extends on all sides: as a consequence, each newly-formed layer is larger than the one which precedes it, which gives to the laminated layers a conical shape (Plate VIII.). If the crusts are removed, an indolent ulcer with an irregular base and undermined edges is revealed, which is frequently slow in healing. Irregularly rounded, depressed white scars, surrounded by a pigmented areola, are left after the ulcer heals, and are quite characteristic of a past syphilis. *A rupia is pathognomonic of syphilis*, as no other dermatosis assumes such a form.

PLATE VIII.

Early Rupial Syphilide.

PLATE IX.

Tubercular Ulcerating Syphilide, showing lesions in different stages.

The PROGNOSIS of this eruption is not favorable in its severe and generalized forms. It is slow in healing, and death has resulted from sepsis due to absorption of purulent matter beneath the crusts. By careful local and general treatment the majority of cases terminate in recovery.

Ulceration with permanent scar-formation may result from any of the pustular eruptions during the secondary stage. The existence of ulcers in syphilis does not imply, therefore, that the disease has reached the so-called tertiary stage. A papular eruption on the trunk is apt to be accompanied by pustules on the scalp and hairy portions of the leg, as if the papules in these localities had been infected by pus-organisms.

Tertiary Syphilis.

The statistics of Haslund[1] show that **tertiary syphilis** in general occurs in about *12 per cent. of all cases infected.* The *skin* is involved more frequently than any other tissue or organ, and nearly as often as all the other organs combined. If we assume that tertiary lesions develop at the site of the earlier ones from latent virus that is rendered active by irritation or other causes, the increased frequency of skin lesions in late syphilis can be explained by the more frequent implication of the skin during the secondary stage, and its greater liability to traumatisms and irritation.

The **syphilides of the late period** of the disease are the *tubercular or nodular* and the *gummatous.* The former are found in the superficial or deeper layers of the skin as grouped or discrete, circumscribed, brown-red nodules, from the size of a pea and larger, which may coalesce into large, flat areas of infiltration. The nodule or tubercle resembles the early papule in its histological structure, and is considered by some writers to be a more highly developed form of this lesion. In its *early tendency to degeneration and ulceration*, producing atrophy and scarring of the skin, it is closely related to the gumma. Both the nodule and the gumma are considered by many syphilographers as varieties of the same lesion. The tubercular syphilide can exceptionally undergo absorption without leaving a scar. As a rule, it spreads in a *serpiginous* manner, healing with loss of tissue, and advancing by a broken, elevated margin which represents the most recent deposit. In this way it produces lesions with the outlines of circles, segments of circles, and horse-shoe- and kidney-shaped infiltrations. When absorption takes place without ulceration, a clinical picture is formed sometimes closely resembling lupus vulgaris (Fig. 67).

The *serpiginous infiltration,* instead of undergoing interstitial absorption, as in the last form, may ulcerate, become infected, and secrete pus or pus mixed with blood, which dries in the form of yellowish-gray or greenish-black crusts, giving rise to the *tubercular ulcerating* or the *pustulo-ulcerating syphilide.* A part or the whole of the marginal infiltration may break down, and numerous foci are sometimes met with in various stages of development (Plate IX.).

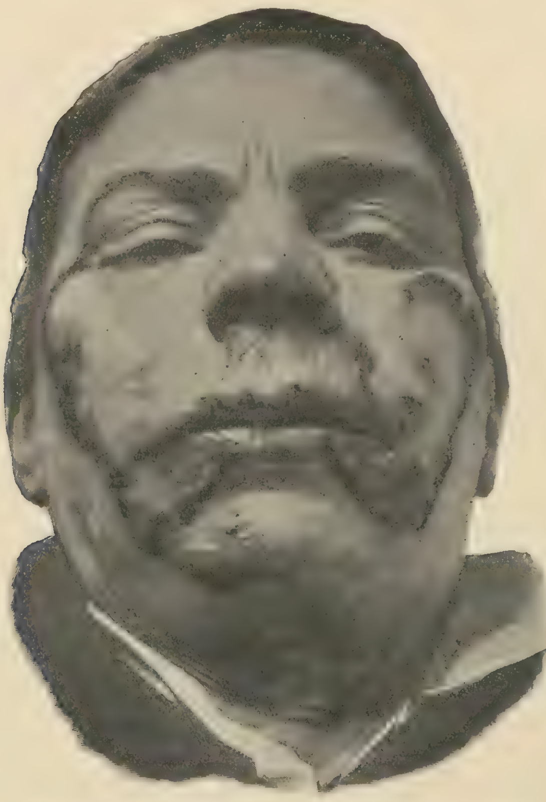
The *entire duration* of the tubercular syphilide may, in severe cases, be *fifteen to twenty years.* The ulcerating serpiginous syphilide develops at times from the papulo-pustules of the late secondary or intermediate period of syphilis. The cicatrices resulting from these forms of syphilide are generally white, superficial, smooth, with scalloped or irregularly outlined borders, surrounded by a pigmented zone, and are quite suggestive of the condition which preceded them. The scar-

[1] "On the Causation of Tertiary Syphilis," *Brit. Journ. of Dermat.*, 1892, p. 210.

tissue is less than would be anticipated from the appearance of the active stage of the disease.

The Gummatous Syphilide.—The *true gumma begins*, as a rule, in the *subcutaneous tissue*, affecting the skin secondarily. It is observed as a round or oval tumor, from the size of a cherry or smaller to one as large as the fist. The gummy tumors in the beginning are hard, elastic,

FIG. 67.



Tubercular serpiginous syphilide resembling lupus vulgaris.

sharply circumscribed, and freely movable beneath the skin, which may not be elevated. This may be painful or only slightly sensitive to pressure. In their development they may become attached to the tissues beneath, as well as to the overlying skin, forming projecting tumors which closely resemble other non-specific growths. The *skin* covering a gumma which has undergone central softening becomes somewhat reddened and swollen, or it may be the seat of a nodular infiltration. An examination at this stage reveals distinct fluctuation: an incision made into the growth gives exit to a thick, viscid, *mucilaginous-looking fluid* of a yellowish-gray color containing *few pus-corpuscles*. The appear-

ance of the contents of the broken-down gumma has given the growth its name. The tumor may be absorbed during the stage of fluctuation, leaving the skin covering its former seat thin, depressed, and somewhat pigmented. The subcutaneous and cutaneous tissues have been in part destroyed by the new growth, so that a permanent atrophy of the affected area remains. The detritus of the gummy tumor at times undergoes a cheesy or calcareous degeneration which becomes encapsulated or is eliminated by ulceration. One or several openings form over a softened gumma, giving exit to disintegrated and sloughing tissue: these openings may unite, forming a single gummatous ulcer, or remain distinct (Fig. 68). The ulcer is at first smaller than the cavity and surrounding infiltration: its edges are thickened, bluish-red, and undermined, its base being made up of the degenerated tissue of the gumma. The ulcer remains open until all the affected tissue has been softened and expelled. The reparative process is slow, and may be complicated and delayed by infection of the surrounding skin, gangrene, phagedena, etc. The ulceration may furthermore extend deeply, involving the underlying muscles and bones. *Necrosis* of the tibia, skull, and other bones follows at times a chronic gummatous ulceration. *Deformity* and contraction may result from deep destruction of tissue about the joints, the lip, or the eyelids. A thickening of the lower extremities, face, and elsewhere, allied to elephantiasis, has followed the destructive process.

FIG. 68.

An ulcerating gumma of the leg.

The *subcutaneous gumma* is generally a single growth: a group of half a dozen or more may be seen, however, which forms a characteristic picture when the stage of ulceration begins. The cicatrices are depressed, circular, white, with a pigmented margin, and may be adherent to the bone or subcutaneous tissue. A group of such scars would suggest the nature of the affection which produced them, while a single cicatrix might not be at all characteristic.

Gummata are the most important syphilitic neoplasms from a surgical standpoint, as they frequently occur without other symptoms of syphilis and closely simulate other conditions. They have been mistaken for abscesses, sarcomata, lipomata of the subcutaneous tissue, for malignant disease of the tongue, the muscles, the breast, etc., and for tuberculosis of the bones, testicle, and other organs. Deep-seated nodules of the subcutaneous tissue are sometimes seen in scrofulous subjects, which

adhere to the skin, ulcerate, and present almost identical features with the syphilitic affection. They are usually symmetrical and heal with scarring, or, if atrophy takes place without ulceration, the loss of tissue may not be pronounced.

These *scrofulous gummata*, or *erythème induré des scrofuleux*, occur most frequently in young girls. In a case recently under my observation the administration of the iodides caused the nodules to break down more rapidly and the ulceration to extend. They healed under local antiseptic applications and cod-liver oil internally.

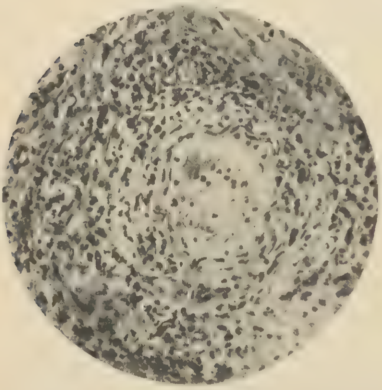
The chronic ulcer of the leg in subjects with varicose veins differs from the gummatous ulcer in its more frequent localization on the lower part of the leg, its chronic course, and in the absence of any feature suggesting syphilis. Syphilitic ulcers occurring in such patients at times lose all their surrounding infiltration and are converted into simple ulcers.

Ulcers following localized gangrene due to obliterative endarteritis, gangrene of the extremities necessitating amputation, and the symmetrical form of gangrene of the extremities—Raynaud's disease—have been observed to develop during the course of syphilis.

PATHOLOGICAL ANATOMY OF THE SYPHILITIC INFLAMMATION.—An implication of the blood-vessels is met with in all stages of the disease. The connective-tissue elements of the vessel, as well as the intima, are the seat of a proliferative inflammation which often leads to its occlusion.

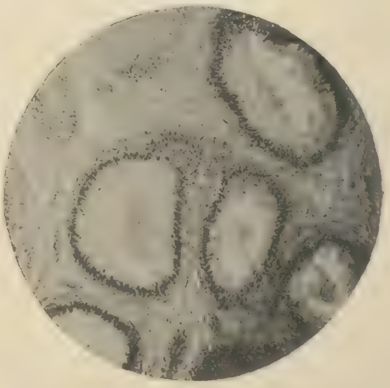
Fig. 69 (a photograph of a section from a secondary papule) shows a fibrosis and leucocytic infiltration of the vessel's coats. The inflammatory cells which are at first confined to the immediate vicinity of the blood-vessel soon become generalized. These cells usually undergo necrosis and are absorbed. The degeneration begins in the oldest part or centre of the lesion, while an active cell-growth takes place at the periphery. This method of involution and evolution of the infiltration explains the ringed and serpiginous outlines which many eruptions assume.

FIG. 69.



Thickening and infiltration of the walls of a vessel in a secondary papule: a thrombus has formed in the lumen of the vessel (× 400).

FIG. 70.



From a syphilitic orchitis, showing the development of connective tissue between the dilated tubules: the tubules are destroyed in other parts of the testicle (× 200).

The necrosis of the cells is more pronounced in certain types of eruption than in others. In the pustular lesions it takes place so rapidly that frequently a typical

papule does not form. In both the initial lesion and in the non-suppurative syphilide the cell-degeneration can be distinctly seen in the microscopic sections. In these lesions, as well as in syphilis in general, there is little tendency on the part of the newly-formed cells to organize into permanent connective tissue.

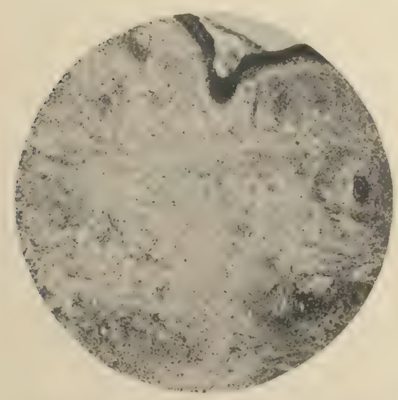
An exception to this rule is found in certain visceral affections due to syphilis where connective-tissue growth occurs, either as a result of the vascular changes in the parts or directly from the action on the cells of the specific virus.

It follows, too, on gummatous deposits in the liver, the lungs, the testicle (Fig. 70), and other organs, causing pressure on and destruction of the implicated tissue. The fibrous tissue which surrounds gummata of the skin and subcutaneous tissue does not show the same tendency to spread as a similar condition in the viscera or nervous system.

In congenital syphilis both the liver and spleen are very often enlarged from an infiltrating growth of connective tissue. The first changes consist of a small-celled deposit about the branches of the hepatic artery or portal canals, which becomes later more generalized and organizes into connective tissue or degenerates into miliary gummata. As the greater part of the arterial blood in the fœtal circulation passes directly through the liver, it can be easily understood that when this blood is charged with the toxines or bacteria of syphilis the first and most pronounced effect may be manifested on this organ.

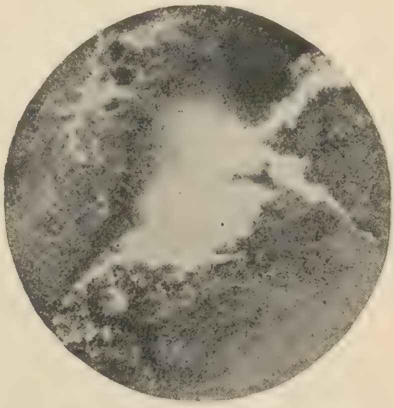
Histology of the Gumma.—These neoplasms begin as small round-celled infiltrations in the connective tissue with a tendency to peripheral extension. Giant cells may be found in the advancing margin. The centre of the gumma undergoes a necrosis which involves not only the recent infiltration, but the connective tissue of the part as well, leading to a permanent destruction of the implicated tissue.

Fig. 71.



Section through a miliary gumma of the skin, showing central necrosis in an early stage (× 80).

Fig. 72.



Gumma of the subcutaneous tissue: advanced stage of necrosis (× 80).

Fig. 71 illustrates an early stage of a miliary gumma of the skin. In the centre of the photograph an amorphous mass of connective tissue is shown, containing a few nuclei and leucocytes. Surrounding the degenerated centre a marked cell-infiltration is present which extends for some distance into the surrounding tissue. In other cases the line of demarcation is more sharply defined. With greater amplification the blood-vessels in the necrotic area are found to be occluded, and those in the surrounding tissue are involved in a manner similar to the vessels in the earlier syphilides.

The blood-vessels of the gumma are not so numerous, nor do they play so important a rôle, a sin the early processes. The characteristic pathological feature of the gumma consists in a degeneration of the connective tissue, of a hyaline and fatty character, which may be expelled or dry into a cheesy mass.

In Fig. 72 a later stage of gumma of the subcutaneous tissue is shown, in which the cellular tissue has been converted into an amorphous mass containing granular matter intermingled with leucocytes and small round cells. Necrosis in the gumma begins in the connective tissue, in the sclerosis, and, in the early lesions, in the newly-formed cells.

In the viscera the contraction of a cavity resulting from a disintegrated gumma results in considerable deformity of the implicated organ; and in the central nervous system, where loss of tissue is of vastly more importance than in the skin, it may produce consequences which are irreparable.

Syphilis of the Mucous Membranes.—Most of the eruptions which are seen on the skin may be found on the *mucous surfaces*, their appearances being altered by the local heat, moisture, and irritation to which they are subjected. A sharply-defined erythema of the fauces and soft palate usually accompanies the macular eruption. A syphilitic vaginitis and urethritis have been noted. It is quite probable that other mucous membranes, which cannot be inspected, are also the seat of similar catarrhal inflammations.

Mucous patches or **plaques**, which represent the cutaneous papule, frequently occur on the genitals of women before the outbreak of the eruption on the skin, their development being favored by local heat and moisture. In this locality and where similar conditions are present, as about the anus, beneath the breast, at the angle of the mouth, etc., the papule becomes abraded, hypertrophied, or is covered by a grayish-white membrane, and at times ulcerates. These *vegetating hypertrophic* and other abraded papules in such places are called *condylomata lata*, to distinguish them from the pointed warts, or *condylomata acuminata*, which are not syphilitic. They secrete a thin, watery fluid and are a potent source of contagion. At the angle of the mouth they may be fissured and painful from the movement of the parts.

Mucous plaques in the mouth arise from the modified papule, and exist in the papulo-erosive, the papulo-hypertrophic, and the papulo-ulcerative forms. The epithelial covering of the lesions is macerated and assumes a grayish-white or opaline appearance. The patches may vary in size, from a line or two to half an inch or more in diameter, and are slightly elevated above the surface. The edge of the tongue and inner side of the lip are favorite sites for them. They show a marked tendency to recur after healing, especially in smokers, and are often seen after other evidences of the disease have passed away.

These late and recurring lesions lose their moist character, become quite smooth, shiny, of a bluish-white color, and may mark the beginning of the condition known as *leukokeratosis*. This affection of the mucous membrane of the tongue and buccal cavity not infrequently follows local syphilitic lesions which have been subjected to chronic irritation. It also occurs in individuals who have never had syphilis and are not smokers. It is not influenced by antisyphilitic remedies,

and must be regarded as the result of the disease rather than as syphilitic *per se.*

Leucokeratosis appears as circumscribed or diffuse smooth patches of a bluish-gray color over the tongue and on the mucous membrane of the cheek, extending backward in radiating lines or bands from the angle of the mouth. The epithelium covering the patches becomes thickened, fissured, and may be the seat of an epithelioma. Its surgical interest depends on the frequency with which it is followed by this malignant growth.

Ulcerative lesions of the tongue or any part of the buccal cavity may follow disintegration of the papule, the nodular, or gummatous deposits. Such ulcerations sometimes spread at their margins, and may assume the outlines of the corresponding cutaneous eruptions.

Gummata of the tongue begin as single or multiple, deep-seated, pea-sized, or larger tumors, over which the mucous membrane may be quite normal. These gummata develop slowly, without pain, and may reach the size of a pigeon's egg before undergoing resolution or breaking down. When they ulcerate a small opening appears over their central portion, which rapidly enlarges to an abscess-cavity.

The *differential diagnosis* between epithelioma and ulcerating gumma is not always easy. In general terms, it may be stated that cancer is usually single, while the syphilitic neoplasm is often multiple. The ulceration in cancer is superficial, painful, bleeds easily, discharges freely, and is often the seat of papillary outgrowths; its edges are more elevated and the induration about the ulcer more pronounced.

The communicating lymph-nodes are soon implicated in the cancerous disease, while they are absent after the late specific neoplasm. An *epithelioma may develop on a gummatous ulceration.* In such a case a differential diagnosis is at times only possible after a microscopic examination.

Interstitial Glossitis.—In late syphilis, as a result of an interstitial sclerosis involving the muscular structure, a part or the whole of the tongue becomes greatly hypertrophied. Later, from contraction of the fibrous tissue, the tongue grows smaller, its mucous membrane becomes smooth, deep furrows form over the tongue which cannot be effaced by stretching, and the organ is harder and less movable than normal. A permanent deformity of the tongue results which is little influenced by treatment.

Hereditary Syphilis.

Syphilis may be *transmitted* by the mother *through the infected ovum;* by the father, *through the infected spermatozoon; or by both parents.* A mother who acquires syphilis after impregnation has taken place may transmit the disease to the fœtus through the *utero-placental circulation.* The later such infection takes place after conception the less probability is there that the child will be affected. When transmission takes place under the last condition—utero-placental infection—the placenta is found to be diseased, and no longer acts as a filter to retain the hypothetical microbe. A child born from a mother who is infected with syphilis in the *late* months of her pregnancy may be healthy, but is *immune* to subsequent infection, as are other healthy children of syphilitic parents

(*Profeta's law*). Such a child may be delicate, anæmic, and have little resisting power to other infectious diseases, or may develop a *late hereditary syphilis.* A healthy *mother* who gives birth to a syphilitic child *from the father may be infected* with the disease through the utero-placental circulation: she may acquire a modified form of the disease, which manifests itself in cachexia, impairment of the general health, or by late syphilitic lesions; she may remain healthy with an acquired immunity to subsequent infection (*Colles-Baumès' law*). When *pregnancy* occurs with *recent syphilis* in one or both parents, it results in the *death* and premature delivery of the fœtus; the birth at term of a dead child; a living child with the disease in an active stage; or of one in which the disease does not manifest itself for several weeks to two or three months after birth. Either parent may, in exceptional instances, transmit the disease after healthy children have been born. The longer the time *between infection* and *impregnation*, however, the *less chance* there is of transmitting the disease by inheritance, and the milder the disease when so conveyed. The infectiousness of the virus is generally weakened by treatment and time, but no one can say when it ceases.

The character of the mother's infection from a syphilitic fœtus, and of the child's infection when the mother acquires the disease after impregnation, probably depends on the occurrence of pathological changes in the placenta. If the *placenta* is diseased and its power of filtration destroyed, the micro-organisms themselves may pass from child to mother and from mother to child, giving rise in both cases to active syphilis. If the placenta is not diseased, it permits the passage of the soluble toxines alone, and a modified form of the disease or a partial or complete immunity to subsequent infection results (Finger, Von Düring).

As the microbic origin of syphilis has not been established, these statements are largely theoretical, but they explain in a satisfactory manner the phenomena of hereditary and placental syphilis.

The PROGNOSIS in *congenital* syphilis is much more *grave* than in *acquired.* The greater number of children born with the active disease die soon after birth. When its symptoms are delayed until the first or second month, if the nutrition is not bad, recovery generally takes place under proper treatment. From one-third to one-half of all cases die before reaching adult life.

SYMPTOMS.—The early symptoms of congenital syphilis appear in the majority of cases within the first *three months*, never later than the *fifth* month. Nearly half the cases present some sign of the disease within the first month. If no evidence of the disease is present during the first *six* months, the child, as a rule, remains well, or at most develops a form of *late hereditary syphilis.*

Syphilitic children are poorly nourished, and remain deficient in both their physical and mental development. They have little resisting power to other disease, and not infrequently acquire tuberculosis, rachitis, or other disorders of nutrition.

Nasal catarrh—*snuffles*—from a specific affection of the mucous membrane of the nose, is one of the most common of the first symptoms of the disease: this is followed or accompanied by a modified erythematous rash, of a patchy character, over the abdomen, about the anus or thighs—by mucous patches and fissures at the angles of the mouth or about other apertures. A generalized erythematous, papular, or a mixed *eruption* is at times present. On the palmar and plantar surfaces, occasionally on other parts of the integument, the eruption assumes a bullous or pustular character. This so-called *pemphigus syphiliticus* develops because of the

delicate character of the epidermis over the specific infiltration. The papules about the anus and mouth readily break down and form superficial ulcers.

Papulo-squamous eruptions may be found localized on the face, the extremities, the trunk, or generalized. Later in life the nodular or gummatous syphilide may be met with, which presents the same appearance as in the acquired disease.

A frequent and characteristic affection of the long bones, known as *osteochondritis syphilitica*, in some cases closely resembling rachitis, occurs early in hereditary syphilis. A swelling takes place at the junction of the epiphysis and diaphysis which may resolve under treatment, or in severe cases ulcerate with extrusion of the diseased epiphysis. Bony union may take place between the epiphysis and diaphysis, or abnormal ossification follow, which can result in shortening or deformity. Parrot's opinion that rickets was always due to hereditary syphilis is not now accepted.

Circumscribed or diffuse thickenings of the bones of the skull, especially the frontal and parietal bones, combined with atrophy of the bone-substance in places, is common in congenital syphilis.

An osteitis and periostitis of the phalanges—*dactylitis syphilitica*—occurs in both hereditary and acquired syphilis.

In addition to the *interstitial* changes in the *liver* and *spleen*, the *lungs* may be the seat of multiple gummata or of connective-tissue growths which may involve a part or the entire lung. This *white hepatization* is harder than normal lung-tissue and contains no air. It may develop after the cutaneous lesions have passed away and yield to treatment, or be combined in later years with tuberculosis.

Hutchinson first called attention to a deformity of the upper central *incisor teeth of the second set* which he looked upon as diagnostic of hereditary syphilis. When cut, these teeth are short, narrow, and thin. After a time a notch is formed by the breaking away of a crescentic portion from their edges, which is permanent for some years. The appearance described is often absent in syphilitic patients, or may result from other causes.

Sudden deafness without pain or purulent discharge in a young person points to hereditary syphilis (Hutchinson). When *deafness*, *interstitial keratitis*, and the *notched teeth* are present in the same patient, the diagnosis of congenital syphilis is looked upon as positive.

Treatment.—Syphilis in healthy individuals of early adult life is, in the majority of cases, a benign affection, often disappearing without treatment, and producing little if any impairment of the general health. Unfortunately, we have no certain means of determining when the disease is cured, or of foretelling the cases that will prove mild and of short duration, and those that may involve important organs and endanger the future health, or even the life, of the patient.

It is, therefore, of the greatest importance to explain to one suffering with the disease the necessity of systematic and prolonged treatment, not only during an active outbreak of symptoms, but during the latent periods as well.

When any doubt exists regarding the character of the primary sore, treatment should not be begun until the *appearance of* the *first cutaneous eruption*. The future course of the affection is probably not at all influenced by such delay, and both the surgeon and patient are assured

of the certain existence of syphilis, and both are more active in carrying out a prolonged treatment than if a doubt exists regarding the diagnosis.

The presence of a sclerosis on extragenital parts or the early occurrence of severe general symptoms during the second incubation-period may be indications for the use of mercury before the characteristic rash has developed. Many surgeons who have had a wide experience with the disease do not hesitate to begin the use of mercury when a characteristic chancre and its accompanying adenopathy are present.

Before the use of mercury is begun the patient should consult a dentist and have the teeth put in good condition. If all cavities are filled and the tartar removed from the teeth, larger doses of mercury can be taken with less liability to salivation.

Alcohol in all forms should be *prohibited* unless some special indication may arise for its use. *Smoking* should not be allowed, as it is apt to irritate mucous patches in the mouth or throat and to determine successive outbreaks of such lesions. Syphilitic mucous patches irritated by tobacco-smoke terminate at times in leucokeratosis and epithelioma. Attention to the ordinary laws of hygiene should be insisted on, and every means employed to preserve the patient's health. Iron, tonics, cod-liver-oil, etc. may at times be indicated in conditions which arise from syphilis, as well as from other causes. They possess no specific action on the syphilitic virus, however, and are sometimes employed for an anæmia which mercury or the iodides can only control.

The *contagious* character of the syphilitic secretions and discharges and the necessity of great care in the family and other intercourse should be explained in detail to the patient.

If marriage takes place during the contagious stage of the affection, or if the disease develops after marriage, the patient must be informed of the danger to the wife and offspring which will follow the advent of pregnancy.

The two *specific remedies* which we possess are *mercury* and *iodine*, the latter usually given as potassium iodide. Certain vegetable remedies, like sarsaparilla and guaiacum, are occasionally used as auxiliaries. *Mercury* exerts a pronounced specific influence over the local and constitutional manifestations of the primary and secondary stages, and it is not without curative effect in the later stages.

The *potassium iodide* causes the rapid disappearance of local lesions and general symptoms in the tertiary stage. It is useful in combination with mercury when early pustular and ulcerative lesions occur, and in the late secondary and intermediate stages of the disease.

Mercury alone is the remedy with which to begin the treatment of syphilis. It may be given by the *stomach*, by *inunction*, by *hypodermic injection*, or by *fumigation*. The most convenient and generally employed method is by the stomach, and in the majority of cases it is not necessary to resort to other means of introducing it into the system. It should be given in sufficient doses to exert a prompt effect on the disease, and yet care must be observed to avoid salivation and diarrhœa.

A persistent *diarrhœa* weakens the patient, impairs the appetite, and causes a too rapid elimination of the drug, so that the specific influence on the disease is

prevented. *Salivation* is injurious, necessitates an interruption of the treatment, and is apt to recur when once allowed to become severe.

There is little uniformity in text-books regarding the best preparation of mercury or the length of time it should be given. It is well to have in mind a number of preparations, as individuals differ in their susceptibility to the various mercurials. *Pil. hydrarg.* in doses of 2 to 4 grains, *t. i. d.*, or *hydrarg. cum creta* in the same doses, may be given continuously for from four to six months. If diarrhœa and pain result, small doses of opium (gr. $\frac{1}{4}$–$\frac{1}{2}$) may be added to one or two of the daily doses of mercury for a short time or until the tendency to diarrhœa ceases. At the same time, the use of fruits and acids should be limited or prohibited; later on, their use may be resumed.

The condition of the *mouth* must be carefully watched, and as soon as the *gums become tender* and swollen or show a disposition to bleed the administration of mercury must be stopped for a few days, or, better, the number of doses or the quantity given reduced.

A wash of alum and potassium chlorate, *āā.* ʒj, to a pint of water, should be frequently used to prevent and relieve this condition of the mouth. Saline laxatives, administered during the existence of a mercurial sore mouth, hasten its cure by eliminating the drug more rapidly through the bowels.

In pronounced ptyalism, with swollen and spongy gums and superficial abrasions of the mouth, mercury should be promptly discontinued. The flow of saliva in such cases is limited by atropine, in doses of $\frac{1}{300}$ of a grain every four hours.

The *mercurial stomatitis* may be quickly relieved by carefully painting the gums with a 2 to 5 per cent. watery solution of chromic acid once a day, in addition to the other measures mentioned, care being taken that the mouth is thoroughly rinsed with water thereafter.

The *protoiodide of mercury*, in pill or tablet form, given in doses of gr. $\frac{1}{4}$ to gr. 1, *t. i. d.*, has had a wide popularity and is largely used as a routine treatment of secondary syphilis. It is not as efficient as the other preparations mentioned, and is apt to give rise to gastro-intestinal irritation when used in larger doses.

The *tannate* of mercury, in doses of from $\frac{1}{2}$ to 1 grain, *t. i. d.*, is an active drug, and is said to produce less stomach and bowel disturbance than the protoiodide.

For the relapsing eruptions of the late secondary stage it is sometimes of advantage to give the biniodide of mercury in doses of $\frac{1}{24}$ to $\frac{1}{8}$ of a grain dissolved in an excess of iodide of potassium. The following formula may be employed:

℞. Hydrarg. biniodid.,	gr. j–ij;
Potass. iodid.,	ʒss;
Aquæ dest.,	℥iij.—M.

SIG. ʒj, well diluted, an hour after eating.

When early pustular and ulcerative lesions are slow in healing the quantity of the iodide in the last prescription may be increased.

During the first six months the use of one or another of the preparations mentioned should be kept up pretty constantly. At the end of this time, if no symptoms of the disease are present, medication may be discontinued for a month or six weeks, and then resumed for three or four months. A longer period of rest may then be permitted, followed by a third course of mercury or mercury combined with the iodide.

If the patient's health keep good and no indications arise against its use, a fourth or fifth mercurial course may be advised.

Inunction Treatment.—This method has the great advantage of not so readily disturbing the digestion, and when, for any reason, the internal use of mercury is not well borne inunctions should be advised.

It is the most *efficient* and *rapid* method in causing the symptoms to disappear. It is disagreeable, uncleanly, cannot readily be concealed, and requires considerable time to be properly carried out.

At health-resorts, like Hot Springs in Arkansas or Aachen in Germany, where experienced rubbers can be employed, it is the method which is almost exclusively used in early syphilis.

The patient should be directed to rub one drachm of the *unguentum hydrargyri* each day, for a period of twenty to thirty minutes, over a limited portion of the integument until the body has been completely covered. The legs may be chosen for the first day, the thighs the second, the back the third, the arms the fourth, and the chest and abdomen for the fifth day. At the end of this time the same course should be repeated. From thirty to fifty inunctions may be given, followed by a period of rest for a month or six weeks. At the end of this time another inunction-treatment should be employed or mercury given by the stomach.

In syphilis of the viscera or nervous system the inunctions can be advantageously combined with the administration of the iodides.

Hypodermic Treatment.—Of the many soluble and unsoluble salts of mercury which have been advocated for hypodermic and intramuscular injections, corrosive sublimate is probably the most efficient and least dangerous. The following formula and method are given by Cooper[1] for its employment:

℞.	Hydrarg. bichlor.,	gr. xxxij;
	Ammonii chlor.,	gr. xvj;
	Aquæ dest.,	℥ij.—M.

SIG. Ten minims to be used for one injection.

The injection should be given through a platino-iridium needle previously sterilized. The gluteal region is the most convenient site to be chosen. The point of the needle is inserted into the gluteus maximus muscle and the solution slowly injected. One injection a week is given for six or seven weeks, and then at longer intervals. By means of these intramuscular injections a sure and rapid mercurialization of the patient is effected, and in certain emergencies they are to be recommended. As a routine method of treatment, however, they cannot be advised, and few patients will submit to them.

Local treatment is often necessary for certain lesions of the secondary and tertiary stages. For the condylomata lata about the genitals, anus, and other regions the free use of *calomel* is the most efficient agent.

Mucous patches on the lips and mouth should be cauterized with the nitrate-of-silver pencil or a chromic-acid solution (gr. xx–xxx to aq. ℥j).

Ulcerations in the *throat* may be sprayed with a solution of bichloride of mercury (gr. ss–j to aq. ℥j).

Localized eruptions disappear more rapidly after the application of an ointment containing mercury. When on the face, a dilute ammoniated mercury or calomel

[1] *Syphilis*, Alfred Cooper, 2d ed., 1895.

ointment should be employed to avoid the stain left by the blue ointment. Specific infiltrations of the tertiary stage are favorably affected by the local use of mercurial ointments or plasters. Mercury is contraindicated in syphilis when tuberculosis exists, in nephritis not due to syphilis, and in pronounced anæmia from other causes. Pregnancy is an indication for its vigorous employment.

Congenital syphilis should be treated by hydrarg. cum creta, gr. j, *t. i. d.*, or, better, by the use of inunctions of blue ointment, gr. xx, once a day, thoroughly rubbed into the body. The ointment should be diluted with vaselin, to prevent its irritant effect on the delicate skin of the infant.

Indications for the Use of the Iodides.—The iodides are frequently given between courses of mercury or after the completion of the mercurial treatment, for the purpose of rendering soluble and eliminating the mercury which may remain in the tissues. Their most striking effects are produced in the late stages of the disease in causing the rapid disappearance of gummata, and other specific infiltrations, and in the healing of syphilitic ulceration of the skin and mucous membranes. No other therapeutic agent can produce so marked and rapid effects as the iodides in late syphilitic neoplasms.

Iodide of potassium is the preparation generally used. It is well to prescribe it in the following manner:

℞. Potass. iodidi,	℥j;
Aquæ,	℥ij.—M.

Sig. Take twenty drops in a tumbler of water after each meal. To be gradually increased. The initial dose need not be larger than 10 grains, three times a day; it may be increased by adding two drops to each dose until the daily quantity taken amounts to 100 grains or more. When the symptoms begin to yield it is not necessary to increase the dose.

In gummatous ulcerations of the mucous membranes and in visceral syphilis, where a rapid effect is desired, the initial dose may be larger than that indicated, and the quantity increased more rapidly.

Certain persons are very sensitive to the iodides, small doses producing catarrhal symptoms in the nose, throat, and bronchial tubes. *Tolerance* of the drug in such patients may generally be acquired by beginning with minute doses and slowly increasing the amount taken.

Papular, pustulous, bulbous, erythematous, nodular, and purpuric eruptions are at times produced by the ingestion of the *iodides*. Certain of these eruptions may be confounded with syphilitic lesions.

It is generally stated that the iodides only relieve the symptoms in late syphilis, and have no direct curative effect. On this account a course of the iodides is followed by the prolonged use of mercury. We have no proof that such is the case.

In certain chronic ulcerations of the skin and mucous membranes in cachectic subjects who prove rebellious to the iodides and mercury large doses of the decoction of sarsaparilla or Zittman's decoction sometimes exert a beneficial influence in starting the healing process. The tissues may become habituated to the prolonged use of mercury and the iodides, and fail to respond in a prompt manner to their use.

Cachectic subjects of syphilis, who do not do well at home, are sometimes promptly benefited by a visit to Hot Springs in Arkansas or Aachen, Germany. The use of the hot tub- and vapor-baths employed in these places increases tissue-change, enhances the effect of the remedies, and improves the general health.

CHAPTER XI.

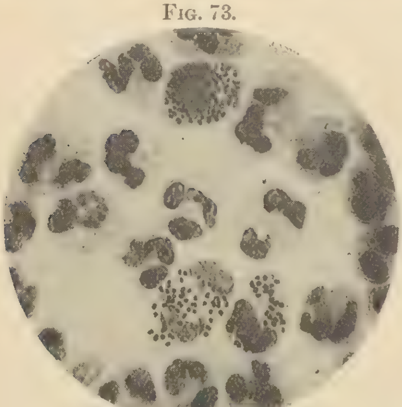
GONORRHŒA AND ITS SEQUELÆ.

By W. T. Belfield, M. D.

Etiology.—*Gonorrhœa is an infection of human tissues by a specific bacterium*, the micrococcus or *gonococcus* of Neisser, reinforced by one or more varieties of the common pus-bacteria; practically, it is therefore a *mixed infection.*

The gonococcus is not only an *obligate* parasite—never found except in animal tissues—but it is also a parasite of *human* tissues only, other animals, so far as known, being an unfavorable soil for its growth. Hence it is acquired only by contact, direct or indirect, with a sufferer from the disease. The commonest seat of the infection is the genito-urinary tract of male and female, and it is hence usually transmitted by sexual contact. Yet certain other *mucous* membranes are susceptible to the infection, and it is occasionally carried indirectly—by soiled fingers, towels, and syringes, or by unnatural intercourse—to the mucous membrane of the eye and rectum, even of the mouth and nose.

Fig. 73.



Gonococci in fresh gonorrhœal pus; × 1000 (Fränkel and Pfeiffer).

While all accessible mucous membranes may be infested by the gonococcus, yet those lined with cylindrical epithelium seem to afford more favorable conditions for the parasite than do the flat-celled membranes; and the disease persists more obstinately in the former than in the latter—in the uterine cervix, for example, longer than in the vagina.

While the infection always *begins on a mucous surface*, it does not always remain limited to these: it may spread by continuity to the submucous tissues, by the lymph-stream to the nearest lymph-nodes; it may enter the blood-current and produce metastatic infections in distant structures—serous membranes and fibrous tissues of joints, bursæ, tendon- and muscle-sheaths, pleura, peritoneum, meninges, peri- and endocardium—constituting a veritable *pyæmia* analogous to that which follows wound-infections.

Morbid Anatomy.—The gonococci implanted during intercourse within the meatus multiply rapidly, and penetrate the epithelium and the subepithelial structures, their presence and products causing that reaction of the tissues which is called *inflammation*, and is manifested by

swelling, reddening, and desquamation of the urethra. Through the gap in the protecting epithelium thus made by the gonococci the pus-microbes—which easily gain access from without, and are indeed often present in the normal urethra—find a favorable soil and reinforce the specific bacteria. The rapidly-multiplying parasites spread along the mucous membrane and submucous lymph-spaces.

The extent of the invasion varies: in a minority of cases it is limited to the penile urethra; in a decided majority it continues through the deep urethra; in a large number it proceeds farther, by way of the ejaculatory ducts, into the dilated extremity of the vas deferens—the ampulla—and into the seminal vesicle; in a considerable number it is further propagated along the vas deferens to the epididymis, thus involving the entire genital canal.

The *urinary channel proper*—that is, above the union with the seminal canals—commonly escapes, the infection ceasing at or about the urethro-vesical orifice. Sometimes, however, the trigone becomes involved, and occasionally the bacterial invasion and consequent inflammation ascend the ureters to the kidney-pelvis and even to the renal tubules.

In the *female* also the extent of invasion varies: the vulva and urethra may alone be infected, though usually the cervix uteri is included; the vagina, paved with squamous epithelium, seems a less favorable soil, though inevitably contaminated by the discharge from vulva and uterus. The infection often traverses the uterine body to the Fallopian tubes, and through these to the ovaries and surrounding peritoneum.

The many *follicles* and pockets which line the genital canal of either sex are naturally included in the bacterial invasion: in the male, the numerous lacunæ of the urethra, Cowper's glands, the prostatic utricle and glands; in the female, the lacunæ of the urethra and urethro-vaginal septum and the vulvo-vaginal glands.

This is a fact of great clinical importance, for long after the general surface has recovered its normal condition and the patient is apparently well, the gonorrhœal infection may persist in some of the hidden pockets in quantity sufficient to infect a partner in the sexual act, and even, when favored by alcoholic or sexual excess, to reinfect the genital canal of the individual himself.

The *serous* and *fibrous* structures which may become the seat of metastatic infection through the blood-current exhibit all grades of reaction, from serous hyperæmia to purulent inflammation, the effect depending, in part at least, upon the varieties of bacteria concerned in the process.

Diagnosis.—Until the discovery of the *gonococcus* in 1879 there was no distinctive feature by which a gonorrhœal infection could be distinguished from other purulent inflammation of the genital tract; hence there occurred many errors in diagnosis, and by consequence many false conclusions as to therapeutics.

For years after Neisser's discovery it was generally assumed that the gonococcus constituted an absolute diagnostic feature; that it was never found except in cases of infection; and that its presence even in small numbers constituted absolute evidence of such infection. In later years, however, it has been proven that a diplococcus, indistinguishable by any laboratory test from the gonococcus, is occasionally found in the normal urethra and vagina, as well as in certain purulent discharges, such as the vulvo-vaginitis of children, where gonorrhœal infection is at least improbable. Whether this non-pathogenic organism is a distinct species of bacterium—a *pseudo-gonococcus*—or whether it is the gonococcus exhibiting, like the Klebs-Löffler bacillus of diphtheria, a wide range of virulence, are questions for the future to answer. But with our present knowledge we must admit that a

diplococcus indistinguishable from that of Neisser may be present in small numbers in discharges which are not gonorrhœal, and hence that the microscope cannot in every case distinguish between gonorrhœal and non-gonorrhœal infections.

When, however, a profuse purulent discharge presents *large numbers of gonococci enclosed in both pus and epithelial cells*, we are warranted in a diagnosis of gonorrhœal infection. In practice, it is only the slight, chronic gonorrhœal discharges, containing but few gonococci, which can be confounded with the non-gonorrhœal discharge containing the *pseudo-gonococci*; and since cases of chronic gonorrhœa or gleet are exceedingly numerous, and cases of non-gonorrhœal urethritis exhibiting the pseudo-gonococci are quite rare, the detection of the characteristic diplococcus furnishes a very strong presumption of gonorrhœal infection, even when the discharge is slight and the cocci few.

The clinical distinction between gonorrhœa and other purulent inflammations of the genital tract is even less trustworthy: it is true that an acute urethritis, beginning from three to seven days after suspicious connection in one who has for a long time had no urethral disease may safely be pronounced gonorrhœa; but there are numerous cases of urethritis which do not conform to these conditions, and in which the clinical diagnosis can be only a probability.

In practice, the differentiation of the gonorrhœal from other purulent inflammations of the genital tract must often rest upon both clinical and microscopical evidence. We may divide all such inflammations in the male into four classes:

1. **Gonorrhœal infection from without**, marked clinically by an *incubation* of three to seven days (usually), and a severe inflammatory reaction in a patient previously free from urethritis: the microscope shows an abundance of gonococci contained in both pus and epithelial cells.

2. **Gonorrhœal infection from within** (*auto-infection*, the "*bastard clap*" of the older authors), marked clinically by an incubation of six to twenty-four hours, and slight or no pain, in a patient with a history of uncured urethritis, as shown by slight gleety discharge, gumming of the meatus, or merely pus-threads in the urine; the microscope shows gonococci, but less numerous than in the first class of cases.

These two classes include over 90 per cent. of all cases of purulent urethritis in the male.

3. **Non-gonorrhœal infection from without**, beginning within twenty-four hours after connection, with slight inflammatory reaction, in a patient previously free from urethritis: the microscope shows *no gonococci*, or at most a few, with an abundance of pus-bacteria. Such cases occur especially after excesses in alcohol and venery with a woman suffering from leucorrhœa, notably when at or near her menstrual period.

4. **Non-gonorrhœal infection from within.**—This may be an extension to the anterior urethra of an inflammation in the bladder or prostate due to vesical calculus, enlarged prostate, gout, or other cause. It is not rare in elderly men suffering from these complaints, and is of mild degree; no gonococci are visible.

In this category one must classify cases of urethritis from *injury*, as by urethral instruments; from *caustic injections* for the prevention of gonorrhœa, etc., in which the history plainly indicates the cause. The

possibility that a mild urethritis following connection may be due to an urethral chancre should never be forgotten; the diagnosis is made by inspecting the fossa navicularis.

Conditions favoring Infection.—It is certain that not every sexual act with an infected woman conveys the infection, for it is repeatedly observed that of several men who cohabit with the same woman in the same night, one will acquire, another escape, the disease. To this result doubtless several factors contribute: the natural susceptibility of different urethras must vary, some having greater natural immunity, some having acquired such immunity by repeated infections with the gonococcus. Moreover, influences which depress the vitality of the urethral tissues, such as excessive drinking, favor infection; and prolonged sexual excitement, by which the naturally acid fluids of the urethra are rendered alkaline, must have the same effect, because the gonococcus grows well in alkaline, poorly in acid, media. A profuse and acrid leucorrhœa of the female, especially when heightened by the congestion incident to menstruation, must similarly favor the transfer of infectious material.

The prevention of gonorrhœal infection after exposure is impossible. Thorough washing of the parts and immediate urination doubtless contribute to that end, but are often ineffectual.

The use of caustic injections after the act is to be condemned: they may be relied upon not to remove nor destroy the infectious material, but to irritate the epithelial lining of the urethra, and thus pave the way for bacterial growth.

The popular belief that a true gonorrhœa can be acquired from a non-gonorrhœal leucorrhœa or menstrual discharge, or from a "strain," is erroneous; while it is doubtless true that a simple and brief urethritis can be so acquired. Gonorrhœa in a patient proves the pre-existence of the disease in another person and the transfer of infected matter.

The disease is occasionally *transferred without sexual contact*, by means of infected towels, syringes, urethral instruments, etc. The patient should be warned to *protect his own eyes*, as well as the persons of others, from such accident; and the physician should be most careful to sterilize all urethral and vaginal instruments after each use of them, particularly upon a case of even suspected gonorrhœa.

Dr. Wishard personally observed the following instance of innocently-acquired gonorrhœa in a virgin: A lady, having contracted the disease from her husband, used a syringe for vaginal injections; an unmarried sister, living in the house, used the same syringe on her own person for the relief of constipation, and thus infected the rectum with gonorrhœa; the purulent discharge from the anus infected the vulva, vagina, and urethra.

CLINICAL HISTORY.—During a period of incubation varying from two to fourteen (usually three to five) days after exposure no evidence of disease attracts the patient's attention: then an *itching sensation*, a *swelling*, reddening, and gumming of the meatus, and a *smarting pain* during urination, are observed, soon followed by the appearance of *thick pus;* these features become rapidly intensified, until in a few days the severe inflammation extending along the penile urethra is manifested by great swelling of the meatus, œdema of the prepuce, redness, often excoriation of the glans, heat and soreness of the entire penis, and a constant discharge of thick yellow or greenish pus. During this period the passage of urine causes acute pain; the stream issuing from the meatus is small, twisted, or scattering. As the inflamed tissues sur-

rounding the urethra are less distensible than normal, *erections*—which are apt to be frequent—are exceedingly *painful* and often distorted, the penis presenting a more or less sharp curve whose concavity is usually downward, sometimes also laterally: this is the condition called **chordee.** There is usually a slight rise of the body-temperature. Seminal emissions during sleep are increased in frequency.

This condition persists, if untreated, for ten to fifteen days, when the symptoms gradually subside: the purulent discharge may persist for several weeks after pain and soreness have ceased.

Such is the clinical history of gonorrhœa when limited to the penile urethra. Yet in a decided majority of cases the disease is not so limited, and other important clinical features are added. These have been generally described as *complications of gonorrhœa*, but are really essential features of the disease, though no one occurs in every case, and some are seen in only a minority of cases. But it is an error—though formerly a prevalent one—to consider gonorrhœa a disease of the penile urethra, and its natural extension to deeper parts as complications.

These extensions are designated by the name of the tissue or organ invaded: the infection may attack the entire genital canal, the urinary tract, the peritoneum where contiguous to these, and the blood-current itself. These will be considered in natural sequence.

Balanitis, an extension of the infection to the *glans penis*, often occurs in slight degree. In exceptional cases, especially where cleanliness is neglected or impossible because of phimosis, a severe infection of the glans and corona occurs, causing extensive erosions, even ulcerations.

Folliculitis, extension of the infection to the *lacunæ* and *follicles* branching off from the urethral canal, always occurs; but so long as the pus produced in these follicles is freely discharged into the urethra no distinct clinical phenomena are induced. If, however, the orifice becomes occluded, the follicle becomes distended with pus: when located near the *fossa navicularis* these distended follicles protrude on the external surface, on one or both sides of the frenum, as hard, tender nodules as large as buckshot. In a few days these usually soften, discharge externally, and heal spontaneously: sometimes they discharge internally into the urethra, and exceptionally in both directions, making a urinary fistula that it may be difficult to close.

Periurethral Inflammation.—When, however, these inflamed and distended follicles are located behind the fossa, the course of events is not always so simple: while the follicle may discharge externally without complications, yet the inflammation may involve the periurethral tissues, making a hard, distinct tumor as large as a hazelnut. This may remain unchanged for months, or it may become the seat of a rapidly-spreading suppuration: the pus sometimes empties into the urethral canal, sometimes rapidly infiltrates the spongy or cavernous bodies. In either case the urine may escape into the periurethral tissues, causing the so-called urinary infiltration: abscess and fistula, septic phlebitis, embolism, and pyæmia, are all possible unless incision and drainage of the infiltrated tissues be promptly made.

These processes destroy more or less of the normal periurethral tissues: the cicatrix by which they are ultimately replaced may later

constitute a stubborn stricture, and even occasion a notable deflection of the penis from its normal straightness during erection.

The clinical signs of diffuse periurethral inflammation are those of septic infection in general: pain at the site of the inflamed follicle, at first dull, then acute and aggravated during urination and erection: diffuse suppuration and urinary extravasation (the latter usually follows soon upon the former) cause throbbing pain, a dark-red œdema, chills, and high fever.

Cowperitis is the designation given to the same process occurring in the two large follicles (glands of Cowper or Méry) which are situated between the layers of the triangular ligament in the perineum and open into the membranous urethra. It occurs after the tenth day of the disease, and occasions a tense, painful swelling in the perineum, noticed especially by the patient when sitting. In all respects, except the anatomical surroundings, it is identical with folliculitis of the anterior urethra.

Prostatitis.—The prostatic urethra is provided with thirty or more glands or follicles, besides the relatively large follicle termed the *utricle*, or *masculine uterus*. When the gonorrhœal infection invades this portion of the urethra (causing the so-called *deep urethritis*), these numerous follicles are invaded by the gonococcus; and there may result a periurethral inflammation and suppuration, just as in the anterior urethra. This process is in this locality called *prostatitis*. Periurethral suppuration and infiltration of urine may occur, the pus and urine burrowing into the pelvic connective tissue or the perineum, and the abscess pointing into the rectum, suprapubic space, or perineum.

Septic infection from the prostatic urethra is especially prone to cause phlebitis, peritonitis, and pyæmia. Fortunately, folliculitis of the deep urethra or prostatitis usually terminates by spontaneous evacuation of the pus into the urethral canal.

Deep Urethritis.—In a majority of cases of gonorrhœa the infection extends in the second or third week through the membranous and prostatic urethra to the bladder. This extension is usually indicated by distinct symptoms which proceed from the irritation of the prostatic urethra. Normally, this portion of the urethra exhibits a *triple function:* in it originates the impulse to urinate; it is intimately concerned in erection and seminal ejaculation; and it is a sphincter of the bladder. Hence the disturbance of its tissues by the gonorrhœal infection causes three notable symptoms: (1) *increased frequency* in the desire to urinate; (2) *prolonged erections* and *frequent emissions;* and (3) marked *difficulty in expelling* the urine, sometimes amounting to complete retention, compelling the use of the catheter. A dull pain, a sense of heat and weight in the perineum, rectum, and suprapubic region, and a sharp pain at the end of urination and referred to the glans penis, accompany all but the mildest cases. The last urine evacuated is apt to be mixed with blood, varying in quantity from a few drops to a light hemorrhage.

Ampullitis and Vesiculitis.—The extension of the inflammation to the dilated extremity of the *vas deferens* (*ampulla*) and the *seminal vesicle* occurs in a percentage of cases as yet imperfectly determined, but probably almost as often as deep urethritis; for the clinical distinction between the latter and vesiculitis has not always been made. The chief symptoms marking the extension from the prostatic urethra to the

seminal tubes are the pronounced *heat* and *pain in the rectum* and the large admixture of *blood* and *pus* with the *seminal discharge*. The examiner's finger, introduced into the rectum, easily recognizes the swollen, tense, and tender vesicles above the prostate.

Epididymitis and Orchitis.—The further extension of the gonorrhœal infection along the vas deferens finally involves the *epididymis*, and sometimes the *tubules* of the adjacent testicle itself. *Epididymitis* occurs in from 5 to 20 per cent. of cases of gonorrhœa, rarely appearing before the third week. The first *symptoms* noticed may be increased frequency of urination, then pain and tenderness either in the testicle or at the external *inguinal ring*. Sometimes a chill and fever usher in the local swelling; in a day or two the epididymis has become swollen, tender, and exceedingly painful, the skin covering it dark-red and œdematous: the testicle usually participates in the swelling and pain.

All these symptoms begin to recede in four or five days, and subside in two weeks, except that hard, sensitive nodules may remain in the epididymis for many weeks, even months. In exceptional cases suppuration and local necrosis occur in the epididymis and testicle.

Cystitis of gonorrhœal origin is usually limited to the vicinity of the *vesico-urethral orifice:* many cases so called because of the frequency and pain in urination, are really instances of prostatitis and deep urethritis.

Ureteritis, pyelitis, and **suppurative nephritis** are infrequent extensions of the gonorrhœal infection: they are marked by chills, fever, and pain, referred to the region of the kidney, the course of the ureter, the testicle, and the thigh. An enlargement of the kidney is often perceptible. The pus passed with the urine is greatly augmented, and there is more albumen than the pus accounts for.

Lymphangitis and Adenitis.—The lymphatics surrounding the urethra are always invaded by the gonorrhœal bacteria, and some of the inguinal nodes are usually slightly swollen and sensitive; in the severer cases a lymphatic vessel along the dorsum of the penis is perceptible as a hard, sensitive cord leading to the inguinal nodes, which are distinctly swollen, and in exceptional instances suppurate (*suppurating gonorrhœal bubo*).

Œdema of the prepuce is frequent in the first week of the urethritis, subsiding as the more acute symptoms lapse: sometimes the œdema is so great as to constitute a veritable *phimosis*, or, if the patient retracts the swollen foreskin, he may be unable to return it, presenting the condition called *paraphimosis*. The latter is an unpleasant complication, because the narrow orifice of the retracted prepuce so constricts the penis as to cause great œdema of the glans, and in occasional instances —fortunately, rare—extensive necrosis and sloughing in front of the constricting ring. Usually, however, this ring itself sloughs away, the strangulation of the glans is relieved, and the swelling gradually subsides.

Post-gonorrhœal arthritis, often miscalled **gonorrhœal rheumatism,** occurs in only 2 or 3 per cent. of cases of gonorrhœa, and is caused by the infection of various tissues by means of the blood-current. It begins at any time, from three days to three months after urethral infection, many cases starting in the first month. It affects especially

fibrous structures and *serous membranes*, and exhibits an *acute variety*—beginning with chill, fever, and local swelling—and a *chronic form*, which may be primary or a continuation of the acute. It attacks most frequently the knee-, ankle-, hip-, shoulder-, and elbow-joints and those of the fingers and toes; sometimes only one joint is affected, sometimes several are simultaneously or successively involved. The local inflammation lasts in acute cases two to three months, in chronic cases several years.

Besides the joints, *bursæ* and *tendon-sheaths* are often attacked, especially those of the legs, feet, and hands; the muscles of the neck, the conjunctiva, and iris also become the seat of the infection. The *meninges, peri-* and *endocardium* sometimes participate in the disease, which is then apt to terminate fatally.

The MORBID ANATOMY presents nothing distinctive from lesions of the same structures due to other causes, except that the gonococcus is sometimes found in the inflammatory exudate, especially on serous surfaces.

Pyæmia.—As the gonorrhœal infection includes the pus-microbes as well as the gonococcus, we can understand that a real pyæmia, differing in no respect from that proceeding from a septic wound, may follow a gonorrhœal urethritis. Such is really the case, though, fortunately, in rare instances.

TREATMENT.—The rational treatment of gonorrhœa—the destruction of the invading bacteria—is as yet undiscovered: it should be distinctly understood that our treatment of the disease is only palliative, and that the infection may steadily advance and long persist in spite of any treatment.

An enumeration of the numerous remedies and methods which have been from time to time recommended, and of the many *specifics* and sure-cures even now current, would fill this volume: only the measures sanctioned by large experience will be here mentioned.

Anterior Urethritis.—The patient presenting himself with a recent gonorrhœa should be first carefully instructed as follows: He should scrupulously avoid constipation, bodily activity, alcohol, and sexual excitement; he should destroy or sterilize by boiling all clothes and handkerchiefs soiled by the discharge, and should wash his hands immediately after every contact with the infected parts or dressings; he should not protect his linen by inserting a wad of cotton under the foreskin (as most Gentiles do), because the cotton dams up the pus in the urethra and spreads it over the glans penis; he should indulge sparingly in meats, coffee, and tobacco, and should keep the horizontal position as much as possible. He should procure a gonorrhœa-bag—a cloth or rubber sack which encloses the penis and is secured by tapes around the waist—or make a substitute by sewing tapes to the toe of a stocking, and place some absorbent cotton in the bottom; in this way the linen is protected, while the pus drains freely from the urethra.

MEDICINAL TREATMENT is *internal* and *local;* the former consists of—(1) *Laxatives*, especially calomel and salines; these are beneficial in all cases, and imperative when there is a tendency to constipation, which must be carefully avoided;

2. *Balsams* excreted by the kidneys, such as santal oil, freshly powdered cubebs, and copaiba. Of these pure santal oil is decidedly the most valuable.

The oil of the shops is usually adulterated (costing two dollars a pound, while the pure oil costs eight dollars), and often disturbs both stomach and kidneys, as is shown by the gastric distress and belching on the one hand, and pain in the loins on the other—symptoms seldom caused by the best qualities of the oil. Good santal oil may be given in ten-minim capsules, beginning with six and increasing to sixteen per day within a week: the dose should be diminished or the remedy discontinued if gastric or renal distress becomes manifest.

Freshly powdered *cubebs*, a teaspoonful every two to four hours, markedly lessens the amount of discharge, though frequently disturbing the stomach; the oleoresin of *copaiba*, a ten-minim capsule six times a day, has a slighter influence upon the discharge, but a greater effect upon the stomach, and occasionally produces an annoying scarlet rash.

Internal antiseptics, so called, such as salol, which when given by the mouth are excreted by the kidneys as carbolic and salicylic acids, etc., have failed to produce the beneficial effect hoped from them, and have been abandoned, though there is still a lingering belief that boric acid, in doses of three to five grains four times daily, does exert a good influence.

3. *Diuretics.*—Water, milk, potassium acetate and bitartrate are useful to dilute the urine and thereby diminish the irritation of the inflamed urethra by contact of this fluid.

Internal medication may therefore be outlined as follows: *calomel* in quarter-grain doses, three to six a day for one or two days; for the next six days a half teaspoonful of *potassium bitartrate* and five grains of *sodium phosphate* in a glass of hot water, night and morning; after which the calomel may be repeated. Naturally, the size and frequency of these doses must be determined by the effect produced.

Twenty minims of good *santal oil* or a teaspoonful of fresh cubebs may be given from four to eight times daily as the stomach permits.

The *local treatment* of gonorrhœal urethritis is exceedingly important: the ancient prejudice against it, based upon the ill effects of severe and caustic injections, does not hold against the later methods.

Of all local remedies, *hot water* holds the first place, and cannot be used too freely nor too often: it should be applied to both the exterior and interior of the penis. This organ should be *immersed*, as often and as long as circumstances permit, in a glassful of water whose temperature may be at first 100° F., and is gradually raised by the addition of hotter water to 105°, 110°, or 115° F. At intervals injections of the same water should be thrown into the urethra. The addition of *boric acid* to the water, a teaspoonful to the pint, enhances the moral, and possibly the physical effect of the water.

Injections into the urethra should be made with a *hard-rubber syringe* holding half an ounce and terminating in a blunt tip without nozzle; and it is wise for the physician to instruct the patient how to inject, both verbally and by administering an injection, and causing the patient to repeat the process in the doctor's presence. Before an injection the patient should empty the bladder: the syringe, filled with hot water (100° F. or more), is held in the right hand, the tip placed carefully between the lips of the meatus, which are then gently compressed laterally by the thumb and fingers of the left hand; by the right hand the piston is pressed slowly and gently home until the urethra feels distended. The syringe is then removed, the escape of the water being prevented by compression of the meatus. After a half minute the water is allowed to escape, and a second injection of hotter water (105° to 110°) is made. After this one of the following solutions is injected: *hydrastin muriate*, saturated solution, or *zinc permanganate*, 1 : 4000 (1 grain to 8 ounces of water).

The hydrastin solution only is used during the acute stage—that is, the first week: thereafter the zinc solution is used first, and then the hydrastin.

It is understood that the hot-water injections are continued. The hydrastin is not irritating, and presents only one disadvantage—the yellow color, which, however, is easily removed by water. These injections should be made from six to ten times per day.

Under such treatment the acute symptoms commonly subside in a week, and in two weeks the discharge becomes slight in quantity and resembles thin milk. When this occurs the hot-water immersions are discontinued and *zinc-chloride* solution, one-half grain to six ounces, substituted for the permanganate.

If the patient can be seen daily, there may be added to the above treatment, at any stage of the disease, even the most acute, a measure recommended by Guiteras—namely, a single daily injection of *silver-nitrate* solution. This should be made by the physician, who injects the first day one to two drachms of a solution containing one grain of silver nitrate to the ounce of water; the second day the solution used contains two grains of the nitrate to the ounce, the third day three, and is thus increased until on the tenth and last day it contains ten grains to the ounce. Occasionally this treatment must be discontinued because of the severe reaction produced.

Various plans have been practised for the purpose of *aborting* a gonorrhœa: these may all be dismissed as certainly useless and often *dangerous.*

Under such treatment as has been outlined perhaps one-third of the cases of acute gonorrhœa are apparently cured in from three to six weeks; but it should be impressed upon the patient that the cessation of free discharge from the meatus does not prove that he has recovered; for long after this stoppage of the flow there may persist various evidences of disease, such as a gumming together of the lips of the meatus, especially during the night; the appearance of a milky drop at the meatus in the morning; and the constant presence in the urine of thick white threads (*clap-threads*) of pus, which soon sink to the bottom of the vessel (these are commonly called by the German name, *tripper-fäden*). The persistence of any of these phenomena indicates the presence of one or more infected areas in some portion of the genital canal, and the case must be considered one of chronic gonorrhœa.

Chordee is not frequent under the hot-water treatment: if it occur, an attempt to prevent it may be made by the administration at bedtime of thirty grains of *sodium bromide* or two grains of *camphor monobromide* with a grain of *codeia.* When awakened by the painful erection, the patient should empty the bladder and apply cold water or a cold metallic object to the penis and perineum. Constipation favors chordee.

Balanitis may be controlled by hot applications of boric-acid solution, followed by vaseline inunctions.

Phimosis is reduced by immersions in hot water and injections of the same under the foreskin.

Paraphimosis needs no treatment but hot water, unless the swelling of the glans seems to threaten necrosis of tissue: in this case the end of a probe-pointed bistoury should be inserted under the constricting band, which is then divided, the incision being dressed with iodoform or aristol.

Folliculitis in the penis needs no special attention unless symptoms

of periurethral suppuration become apparent—local redness, tenderness, and boggy swelling: in such case incision and perfect drainage should be promptly made, followed by hot-water immersions of the septic tissues.

Periurethral suppuration, occurring in any portion of the tract from meatus to bladder, must be recognized early and treated promptly, for it is apt to be followed by urinary infiltration and the severest forms of septic infection. When discovered, whether in penis, perineum, or prostate, the pus should be promptly *evacuated* from the nearest cutaneous surface.

Deep urethritis occurs in the majority of cases of gonorrhœa, and often requires no especial treatment; indeed, it is often unnoticed by both patient and physician. In more severe cases, when frequent and difficult urination, pain in perineum and rectum, and some fever attract attention, the patient should remain in bed, take frequent hot-water fomentations, hip-baths, and enemata; the perineum should be irritated by mustard plasters or even blistered by cantharidal collodion; and the pain and straining to urinate, often agonizing, quieted by morphine; complete retention of urine, requiring the use of the catheter, is not unusual. Not infrequently these severe symptoms are suddenly relieved by a discharge of pus from the prostatic follicles into the urethra; but occasionally the pus burrows into the perineum, vesico-rectal or suprapubic tissue, requiring prompt evacuation.

Vesiculitis and **ampullitis** often follow closely upon deep urethritis, from which they can be distinguished by the finger in the rectum, revealing an oblong, tender swelling on one or both sides above the prostate. *Rest* in bed, hot *hip-baths*, and enemata, and morphine should be used until the more acute symptoms subside; then with a finger in the rectum gentle pressure toward the prostate should be made. Sometimes this manipulation is rewarded by a gush of foul pus through the urethra and meatus, and rapid subsidence of both swelling and symptoms. If, however, the effect fails and the symptoms increase in severity, an *incision* should be made into the sac *from the rectum*, the cavity washed out and lightly packed with gauze.

Epididymitis can usually be aborted by painting the skin along the cord and epididymis with *guaiacol*, using fifteen to thirty minims for each application, and making three applications in the first twenty-four hours, and two each day thereafter for a few days. The skin is usually peeled by the guaiacol, and the excoriations should be dressed with vaselin.

Both *testicles* should be *held up* against the symphysis in the following manner: The entire scrotum is enveloped in a thick layer of cotton, which is covered with oiled silk or sheet rubber, surrounded by a gauze bandage, and the whole raised and supported against the symphysis by a jockey-strap or a silk handkerchief pinned to the underwear. The cotton should be changed every day. By the early use of guiacol and this bandage confinement to bed can usually be avoided: under other treatment a week's rest in bed is commonly inevitable.

Orchitis.—A certain amount of orchitis usually accompanies epididymitis, and is relieved by the treatment for the latter: the local application of *guaiacol* may be extended over the testicle if this organ is swollen.

If neglected, *suppuration* may occur in the testicle, indicated by chills, fever, and

local softening: this should be treated by prompt incision and drainage. There is usually some protrusion of the testicle-substance through such an incision (*hernia testis*), which, however, is spontaneously reduced as the swelling subsides. *Gangrene* of a portion of the testicle is an occasional event, often indicated by sudden subsidence of pain, and requiring ultimate removal of the necrotic tissue by the knife.

Post-gonorrhœal arthritis, or **gonorrhœal rheumatism,** has until recently been unaffected by any of the numerous remedies tried upon it: treatment has consisted of wrapping the inflamed joints in cotton and oiled silk, placing the patient upon a water-bed and administering anodynes. Inunction of the inflamed joints and tissues with *guaiacol* (not more than two drachms being applied per day) promises better than any medication hitherto advised.

Chronic Gonorrhœa; Gleet.

By common consent, a gonorrhœal infection of the genital tract in the male which persists more than eight weeks is termed a *chronic gonorrhœa*, and the discharge from the meatus, when present, is called a **gleet**.

It has been customary to consider chronic gonorrhœa and gleet synonymous terms, but this is one of the many errors which have descended to us from the earlier surgeons; for by a *gleet* we understand a discharge from the meatus, but the *gonorrhœal infection often persists* in the prostatic urethra and seminal tubes long after the anterior urethra is practically well and without any discharge from the meatus; for the pus produced in the deeper parts may be prevented from reaching the anterior urethra by the cut-off muscle. Hence a chronic gonorrhœa may long exist without a gleet—an important clinical distinction.

Gleet is the continuation of a gonorrhœal discharge from the meatus, and may vary from a *profuse milky* to a *slight watery flow*. Sometimes there will during the day be no distinct discharge, but only a gumming of the meatus; but in the morning, with or without milking the penis, a drop or two of milky fluid appears, the so-called *morning drop*, or, as the French call it, the *military drop*.

While a gleet proceeds directly from the anterior urethra, *the source of the discharge may lie behind the cut-off muscle.* Failure to recognize this fact is the explanation of many failures to stop the discharge: the patient uses one medicine after another, one injection after another, without relief. Or the discharge stops while an injection is constantly used, but reappears when it is discontinued.

The first step toward the intelligent treatment of gleet is therefore the *discovery of the infected area*, which may be found anywhere from the meatus to the vas deferens. For practical diagnosis and treatment the genital surfaces may be divided into three portions: (1) the *anterior urethra* (to the bulbo-membranous junction); (2) the *deep urethra* (from bulb to bladder); and (3) the *prostate*, *ampullæ*, and *seminal vesicles*.

The simplest means for determining which of these three portions is the source of a gleet is called the "three-glass test," which is thus made: The patient, having retained his urine two hours or more, first submits to a thorough irrigation of the anterior urethra through a catheter passed as far as the bulb, whereby all pus anterior to this point is removed; he then passes about an ounce of urine into the first glass (it is best to use small glasses), whereby the pus is washed from the deep

urethra; the physician's finger is then introduced into the rectum and gently presses the prostate and seminal vesicles; the patient then passes another ounce of urine into the second vessel and the remainder into the third. A comparison of the amount of pus in the respective glasses affords a fair inference as to the source of the pus. (A drop or two of nitric acid in each glass will remove any cloudiness due to phosphates, while not affecting pus.)

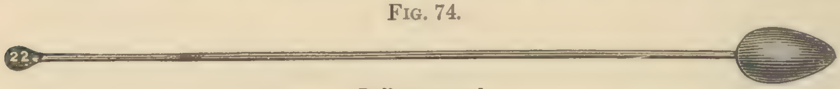
It is chiefly important to know whether the pus-production is limited to the anterior urethra or extends also to the deep urethra: in the latter case some involvement of the prostate and seminal tubes may be expected.

Persistence of suppuration is due to the existence of diseased areas, which are of *three classes:* (1) *plastic exudate* in the submucous tissue, causing a catarrh of the surface and developing into stricture; (2) *pre-existing stricture;* (3) *imperfect drainage,* as in the prostatic follicles and seminal vesicles.

The anterior urethra is explored by—(1) *bulbous sounds* and (2) the *urethroscope* (*endoscope*).

The bulbous sound (Fig. 74) is so shaped as to detect a lack of normal distensibility of the canal; that is, a stricture. This natural distensibility (calibre) varies in different portions of the urethra, being greatest in the bulb and the prostate and

FIG. 74.

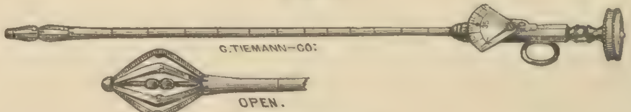


Bulbous sound.

least at the meatus, the scrotal and membranous portions. The calibre also varies in different individuals, maintaining a fairly constant ratio (about four-tenths) to the circumference of the flaccid penis: in general it ranges from 30 to 36 of the French scale. By means of the bulbous sounds any strictures worthy of note can be detected, provided the meatus will admit a bulb of full size. If, as often happens, the natural contraction of the meatus prevents a satisfactory exploration by these instruments, the surgeon must either divide the meatus to 35 Fr. or employ an Otis (or similar) urethrometer. Division of the meatus should never be performed if that orifice admits a 22 Fr. bulb; for, while the operation is trivial, the result is a gaping deformity of the natural nozzle-shaped orifice, whereby the expulsion of urine and semen is unfavorably influenced, and the patient's liability to gonorrhœa and urethral chancre undoubtedly increased.

Instead of cutting a normal meatus, the surgeon should use the urethrometer of Otis (Fig. 75), an ingenious instrument constructed on the umbrella principle:

FIG. 75.



Urethrometer.

introduced when closed, it is dilated by a screw at the handle to the desired size (33 Fr. or more), and then drawn forward, the variations in calibre necessary for its passage being indicated on the dial.

Neither bulbous sounds nor urethrometer should be passed into the muscular portion of the urethra beyond the bulb: the distensibility of this portion of the canal is tested by *cylindrical sounds.*

The *prostatic urethra* is practically *never the site of contractions* (strictures) *as the result of gonorrhœa.*

Inspection of the entire urethral surface can be made through one of the many urethroscopes in use: by it the surgeon may detect diseased areas by the unnatural redness and granular appearance of the surface. While urethroscopic inspection is always desirable in cases of gleet, it is not always essential.

Digital examination per rectum should never be neglected in determining the source of a gleety discharge, even though the anterior urethra is found to be strictured or otherwise diseased; for the prostate and seminal vesicles are often the seat of persistent infection and contribute to the discharge.

To determine the condition of these parts the surgeon's fore finger—best enclosed in a rubber condom which is anointed with glycerin—is introduced into the rectum of the patient, who may either lie upon his back or stand with the feet apart and body bent forward. The finger *first determines whether the prostate is swollen, asymmetrical, or unduly sensitive;* then the finger-tip is made to "milk" the prostatic *follicles* by *gentle pressure* on the organ from above downward (toward the anus): the prostatic *utricle*, which lies between the lateral lobes of the organ, and is often distended with pus, should be included in the milking process. The appearance of a purulent discharge at the meatus during this manipulation shows that the prostatic follicles are diseased.

The finger should then be inserted farther into the rectum, so as to compress or "milk" the *seminal tube* and vesicle on each side: the escape of pus and catarrhal products in notable quantity indicates that these tubes are implicated in the chronic infection.

Treatment of Chronic Gonorrhœa and Gleet.—The treatment of gleet should always be preceded by a determination of the seat of the disease, as already outlined: a routine prescription of injections or use of sounds, while curing a certain number, will fail to relieve many that are amenable to intelligent treatment.

Certain general measures are applicable to all cases of gleet: they should carefully avoid constipation, alcohol, and sexual excitement.

It may be here remarked that instances are not rare in which an obstinate gleet has stopped suddenly and permanently after indulgence in beer or wine by a patient who has long abstained, or after sexual intercourse by a man who has long been continent.

Patients afflicted with gleet should drink plenty of good water and avoid the excessive use of tobacco and coffee.

The special measures required are—(1) *sounds;* (2) *injections*—anterior and deep urethra; (3) *milking of prostate* and seminal tubes; (4) *medicines* internally and locally; (5) *local applications* to diseased patches through the endoscope.

Fig. 76.

Otis' dilating urethotome.

(1) **Sounds.**—A *stricture* should be treated by gradual dilatation car-

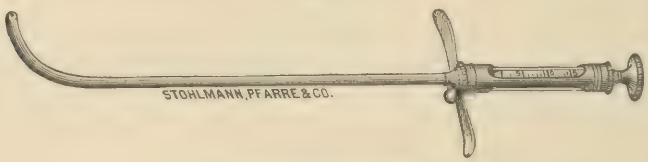
ried to the full calibre of the urethra, 32 to 36 Fr. If a narrow meatus prevents the use of large sounds, the surgeon should choose between enlargement of the meatus (advisable in exceptional cases only) and dilatation by means of special instruments, the dilators of Otis, Tuttle, Oberländer, etc. Even when no decided stricture is detected, the passage of large sounds through the deep as well as the anterior urethra is an advisable accessory to other treatment. The surgeon who possesses one of the special dilators should gradually *overstretch* (by 2 or 3 mm.) any contracted ring.

(2) **Injections.**—Of the multitude of injections recommended for gleet of the anterior urethra the following are useful: *hot water* (100° to 115° F.) alone and containing in solution hydrastin muriate (saturated) or *picric acid, zinc permanganate, nitrate of silver*, one grain to eight ounces: *alcohol* is an old and valuable remedy, beginning with one part in twenty of water, and gradually increasing to one part in five.

Deep Injections.—Liquids injected from the meatus do not ordinarily reach the deep urethra, because arrested by the "cut-off" muscle. Injections into the deep urethra are therefore usually made through a tube introduced beyond the bulbo-membranous junction.

Special syringes for this purpose have been designed by Guyon, Ultzmann, Keyes, and others (Fig. 77), whereby an exact number of minims of a given strong

FIG. 77.



Deep urethral syringe.

solution can be deposited in the deep urethra—a process often called *instillation*. A better practice is *irrigation of the deep urethra* with a larger quantity of a weaker solution. For this purpose a small soft catheter (sterilized) is introduced until the urine flows, then withdrawn about an inch and a half; a five-ounce rubber syringe or small fountain syringe (hung low) is then attached. The solution passes into the deep urethra, and thence into the bladder, the cut-off muscle preventing its escape through the penis; the catheter is then withdrawn and the patient empties the bladder, thus passing the solution a second time over the deep urethra.

The solution used should be hot (100° F.), and may consist of nitrate of silver, one part to ten thousand of water, bichloride of mercury, one to twenty thousand, or permanganate of potassium, one to five thousand, employed every two or three days.

Many patients can with practice *inject the bladder without a catheter*: this is, when practicable, preferable to the injection by catheter, and is accomplished by placing the patient in a reclining position, with thighs flexed upon the body. A fluid gently injected by means of a five-ounce syringe may, after slight delay at the cut-off muscle, flow into the bladder. Elderly men are especially favorable subjects for such injection.

(3) **Milking the prostate and seminal vesicles** is always required when these parts are obviously diseased, and, like the passage of sounds, is sometimes useful even when no infection of these parts is detected.

This manipulation should be performed at first very gently and for only two or three minutes at a time: the pressure used and the time expended may be gradually increased, and the intervals between sittings reduced from six days to three. If the pain caused persists for several hours, the next application should be more moderate, as violent pressure may cause an extension of the infection along the vas deferens to the epididymis.

(4) **Medicines** administered by the mouth cannot be relied upon to influence a gleet: the best effects are obtained from *turpentine oil* in three- to five-drop doses, *santal oil* in ten-minim doses, and *tincture cantharides* in three-drop doses, four to six times daily.

Iron and other tonics are beneficial to a patient showing any signs of anæmia, and sometimes are quite essential to a cure.

In the *suppository* form drugs are applied directly to the prostate and vesicles with benefit when these parts are involved: ichthyol, two grains, ext. belladonnæ or hyoscyami one-quarter grain, may be thus administered three times daily. Syphilitics should take mercury or iodine, and scrofulous subjects guaiacol: in malarial districts quinine may have a decided effect in checking a gleet.

(5) **Local applications** to diseased areas through the urethroscope are sometimes necessary: the diseased surface is brought into the field, cleansed with cotton, and touched with a stick of copper sulphate or a strong (10 to 20 per cent.) solution of silver nitrate, the application being repeated every few days as the course of events indicates.

The treatment of chronic gonorrhœa and gleet may be thus summarized: In addition to the hygienic measures necessary for all, and the tonic treatment required by some, direct measures should be adapted to the part of the genital tract involved: for the anterior urethra, sounds, injections, applications through the endoscope; for the deep urethra, irrigations, large sounds; for the prostate and seminal tubes, the treatment for the deep urethra combined with the milking process and suppositories.

When does a chronic gonorrhœa cease to be contagious? is a frequent and most important question, to which we can give no definite answer. Theoretically, the contagion ceases when the gonococci disappear absolutely from the body, but, practically, we cannot determine when this happy event occurs in a given case. So long as we find these bacteria in a free discharge or even scattered through the pus-threads (*tripper-fäden*), which are passed with the urine long after free discharge has ceased, we believe the individual capable of conveying the infection; but we know that the gonococci may lurk in crypts and follicles of the genital canal even when a careful search fails to detect them in the pus-threads. Under the excitement of intercourse a rapid multiplication of these organisms may occur, resulting in the infection of the woman and the reinfection of the patient's own urethra. This is especially apt to occur in the frequent and prolonged sexual indulgence of recent marriage. Gonococci have been found in the pus-threads three and four years after the last infection.

CHAPTER XII.

SHOCK AND COLLAPSE.

By Roswell Park, M. D.

Under these two terms, which are nearly interchangeable, is described a condition of reflex depression which occurs often after severe injuries or accidents, and often as the result of mental emotions from apparently trivial causes. If one is to distinguish between *shock* and *collapse*, one should reserve the former term for cases which follow injury or accident, and the latter for those cases occurring spontaneously or from mental or intrinsic causes not connected with physical violence. *Shock may be of all degrees*, from the most temporary faintness from which one recovers within a few moments, up to a condition of vital depression which terminates fatally, there being no reaction in spite of all efforts to produce it.

The consideration of shock is more or less inseparable from that of concussion, for instance; and the condition so often alluded to in surgical literature as *concussion of the brain* is but little, if at all, distinguishable from true shock. When we attempt to isolate and define its peculiar features, we find but little more than inhibition of nerve-activity and reflex paralysis. The feebleness and inactivity of the heart are apparently due to reflex irritation of the pneumogastric, or else to reflex vasomotor paralyses, especially of the abdominal vessels. The theory of the causation of shock is a matter of great interest, but one which can scarcely be profitably discussed here. Whether the heart be in large degree paralyzed, or whether the vascular tonus be inhibited so that the vessels expand to their fullest and contain the blood which ought to be passed through the heart—these being the two now generally received explanations; or whether, as is more likely, shock be essentially a combination of these two conditions,—the symptoms are classical and easily recognized.

Symptoms.—These at least can be referred almost solely to vasomotor paralysis, obviously of reflex origin from the peripheral (*i. e.* the sensory) nerves. They consist of an expressionless face, of pallor of the skin and visible mucous membrane, with corresponding coldness of the same (*i. e.* reduction of surface-circulation and heat); of dilated pupils, reacting slowly to light; irregularity of the heart's action, with a weak, irregular, thready, or imperceptible pulse; irregular respiration, breathing being irregular both in rate and depth; mental inactivity and apathy; loss of voluntary muscle-movement; impairment of superficial sensibility; actual reduction of body-temperature; occasionally nausea or actual vomiting. These at least constitute the symptoms in the majority of cases, and form what may called the *apathetic or torpid type* of shock.

Again, we may have shock of the so-called *erethistic type* (Travers), in which patients are restless and excited, uncontrollable, and yet with

irregular pulse and breathing, often with dilated pupils. Finally, we have a third type, described by Travers as the *delayed*, in which the symptoms are as above detailed, but come on only some hours after that which has produced them, but which may be only an expression of concealed (internal) hemorrhage. The delayed type is often seen in those who escape serious accident with a minimum of physical harm.

As shock becomes more pronounced, mental depression deepens into coma, or mental excitement subsides into it; the surface becomes colder and bathed with perspiration; and death follows. These symptoms are those generally noted, whether following injury to the head and denoting so-called concussion of the brain, or loss of blood, or wound of the abdomen with injury to the viscera, blows upon the testicles, gunshot wounds, or other accidents which are notorious causes of shock. They follow also after perforation of the bowel, as in typhoid fever or appendicitis, or fatal cases of empyema, or the depression following the receipt of bad news, or fright, etc.; in other words, the physical condition is practically the same no matter what the exciting cause.

The general subject of shock is one of keen interest to the surgeon, because he is often called to patients whom he finds in this condition, when the question at once arises, Is the necessary operation to be performed at once, or must one wait for a certain degree of reaction? It is of interest also because of the danger in many extreme cases that the necessary operation, so plainly indicated, may be followed by a degree of shock from which the patient may not be revived.

Diagnosis.—Shock has practically only to be diagnosed from *fat-embolism*, or possibly from a general and more or less permanent condition of physical depression. From the latter it is usually easily dissociated; differentiation from the former is not always easy, and it is unquestionable that many patients have died of fat-embolism in whom the actual cause of death has not been appreciated, yet has been ascribed to shock. (See Fat-embolism, Chapter II.)

Shock is sometimes scarcely to be distinguished from other consequences of exhaustive hemorrhage, such as acute reduction of the normal amount of hæmoglobin, save by careful estimation of the latter. (*Vide* Chapter II.)

Treatment.—The treatment of shock consists in those measures by which reaction may be safely brought about. At the very outset one must bear in mind two or three cautions that may not safely be neglected. One is, that it is injudicious to establish reaction too quickly, lest it be succeeded by over-action with attendant disasters in the shape of secondary hemorrhages, etc. Another is, that, volition being so largely destroyed, these patients cannot swallow nor act as they would under other circumstances. It is a mistake, then, to expect a patient suffering from shock to drink strong liquors, for instance, as would one when not so suffering, since a little of the irritating fluid may escape into the larynx and set up a violent coughing-fit which, of itself, might prove fatal. The same is true of inhalations of strong volatile stimulants, like ammonia, etc. These measures, therefore, should all be resorted to with care and discretion. *Cerebral anæmia* is evidently a part of the condition of shock, and should therefore be combated by a dependent position of the head. Hence the patient should be laid flat,

or even with the head lower than the rest of the body—*i. e.* the feet and extremities raised. It is a good plan occasionally to bandage the extremities from their tips toward the body, in order that the blood which they would naturally contain may be pressed into needed service in the vital organs. Should, however, cyanosis be noticed, it may be held that the depression of the head is being overdone. Warm stimulating drinks, if they can be swallowed, are always of avail; and whiskey, brandy, etc. should be given dilute and warm rather than strong and cold. External heat is evidently indicated, and in many cases can be well applied by immersing the patient in a bath-tub of warm water, taking pains only to keep the face out of water. When this be not at hand, bottles and other receptacles for warm water may be applied about the patient, care being exercised not to burn him. Enthusiastic application of too much heat under these circumstances has often been the cause of serious burns with great resulting discomfort. Artificial respiration may be resorted to, or the diaphragm may be stimulated to activity by the Faradic current, applied with one pole over the phrenic nerve, the other over the diaphragm. When the stomach does not retain, or when the patient cannot swallow stimulating drinks, almost as much benefit can be gained by resorting to enemata of hot black coffee with brandy, with ammonium carbonate, etc. Nitrite of amyl will frequently bring a flush to the face, and will relieve vasomotor spasm of the cerebral capillaries and of the body surface, thus helping to equalize the circulation. It will be found sometimes of great value. The principal remedies by which to stimulate the activity of the heart are strychnia and tincture of digitalis, both of which should be administered subcutaneously and in comparatively large doses. A flagging respiration may also be stimulated and sustained by atropia, given in the same way. Under these circumstances, when these drugs are called for, it would be well to give in one hypodermic injection 1 c.c. of tincture of digitalis with $\frac{1}{20}$ of a grain of strychnia and $\frac{1}{100}$ of a grain of atropia. This may be repeated in half an hour or an hour if necessary, while the digitalis alone may perhaps be given at more frequent intervals.

The erethistic or extremely restless type of shock may always be profitably treated by small, at all events sufficient, doses of opium, preferably by morphia, $\frac{1}{8}$ to $\frac{1}{4}$ grain subcutaneously, and repeated *p. r. n.*

Such a case as this requires most careful and constant watching and judicious stimulation, in order that one may stop abruptly when reaction becomes too marked or comes on too suddenly.

When shock is due, in large measure at least, to loss of blood, either by accident or operation, the infusion of a saline solution, consisting of sterilized water 1000, ammonium carbonate 1, common salt 6, may be practised, this fluid being slowly introduced through a hollow needle into one of the superficial veins wherever it may be most easily reached. It should not be introduced rapidly, but may be employed very gradually to the extent of 500, 1000, or possibly even 2000, c. c. of this fluid. It serves to equalize the circulation and to give to the endocardium the stimulus which it must get from a certain volume of fluid of normal specific gravity in order to excite cardiac motions. A fluid thus prepared and used is probably just as efficacious as blood or milk, is much more easily obtained, and serves in every respect as well.

Finally, the question of immediate operation has often to be most carefully considered. There can be no question but that shock is often alleviated by prompt removal of mutilated limbs or parts whose frag-

ments, when still connected with the trunk, seem rather to perpetuate the condition. So, too, prompt surgical attention to severe compound fractures, as of the skull or of the limbs when bone-ends are much displaced or are projecting, seems to be a most important measure and an essential part of the treatment of shock.

CHAPTER XIII.

SCURVY AND RICKETS.

By Roswell Park, M. D.

Scurvy.

Scurvy is an affection by general consent placed among the so-called surgical diseases, manifesting, at all events, many distinctly surgical features and possibly of parasitic character, although this feature of its existence has not as yet been incontrovertibly established. It is in large degree a *starvation* disease, its principal characteristic being that of *mal-assimilation*, accompanied by more or less *profound anæmia*. It has certain points of resemblance to that condition of multiple neuritis met with in warm climates and known usually as *beri-beri*. The former is apparently due to the absence of a vegetable regimen, while beriberi is largely due to the absence of an animal regimen, nature having intended that man's diet should be mixed, and having ordained that suffering and disease practically always follow confinement to one or the other.

As met with in the United States, scurvy is essentially due to the *absence*, from the dietary of the patient, of meats which have not been salted or preserved and of fresh vegetables and fruit. This condition obtains *par excellence* among sailors upon long voyages. But scurvy is misjudged when it is supposed to be solely a disease of those who follow the sea. One meets with well-marked instances of it in overcrowded parts of great cities and among the very poor, while *famine* always and everywhere has been characterized by typical expressions of the same condition. Distinctly scorbutic manifestations have also been seen in individuals far removed from want, in whom they appear to have been produced by simple mal-assimilation. Close confinement also figures as a predisposing cause, and scurvy is noted in prisons and asylums. Physical and mental misery always predispose, and *nostalgia*, coupled with hunger, seems to precipitate, its attacks.

Pathology.—The pathology of scurvy is very obscure. The condition is certainly dependent upon chemical alterations in the blood, without, however, morphological changes which are distinct or pathognomonic. The ease with which hemorrhagic effusions occur, the degeneration of muscles and other tissues, the frequent detachment of cartilages, can, in a general way, be accounted for by conditions thus summarized; for which, however, we have no minute explanation. Moreover, scurvy may so complicate various other diseases, and usually does when occurring in large bodies of men—as in armies, prisons, among convicts, etc.—that it is hard to dissociate morbid phenomena and assign to each its proper place.

Symptoms.—The disease begins by a condition of more or less generalized prostration, with an icteric tint of the skin, malaise, mental torpor, loss of appetite, insomnia, etc. The first recognizable or dis-

tinctive local appearances occur about the margins of the gums. Here, in the intervals between the teeth, the gums become livid, friable, and bleed easily, while the breath assumes a characteristic fetid odor. These appearances are followed by local pains, diversified and sometimes excessive, and extravasations of blood in the skin and under the visible mucous membranes, causing small ecchymoses, which by themselves would be considered as simple purpura hæmorrhagica. These pass through the usual phases of extravasations, while it is made evident by pain, nodular masses, etc. and by post-mortem examination that similar hemorrhages occur in the deeper tissues, especially in the muscles, even in the bones and epiphyses. So easily, in advanced stages, do hemorrhages occur that there is often external bleeding, particularly from the gums and mucous membranes, while from points thus involved pyogenic infection may proceed internally; and at last one sees a picture of, as it were, an animated corpse, with surface discolored and mottled, often appearing terribly bruised, with ulcerations where extravasations have failed to resolve, and where infection has occurred, possibly with epiphyses loosened, and, if time permit, necrosis of bones of the extremities. In such cases death results from marasmus and sepsis.

Treatment.—So long as the patient be not in the desperate condition last described the prognosis and promise of treatment is very good, since all the milder manifestations of scurvy can be completely dissipated by suitable feeding and medication. Loss of teeth and cicatrices of ulcers, of course, leave permanent traces, but function can be completely restored. So far as the *purpura* is concerned, it is simply one expression of the scorbutic condition. Nearly all cases of scurvy will present purpuric manifestations, but by no means all cases of purpura are necessarily scorbutic. The canons of treatment may be summed up in proper diet and in the administration of certain drugs. *Proper diet* should be issued at once, but administered, especially in severe cases, *with extreme caution*. The food selected should be given in small quantities, but frequently. It will consist in large measure of fresh fruits and vegetables, while cranberries and lime-juice figure largely among the former. Buttermilk is excellent, and cider may be allowed; lemonade is also highly commended if it contain not too much sugar.

For the local condition in the mouth an antiseptic mouth-wash containing a fair proportion of hydrogen dioxide is most advisable. Alcoholic stimulants are called for, at least up to a certain point. Strychnia and cinchona preparations will give force to the heart's action and the horizontal position, for a time at least, will prevent sudden heart-failure. The compound syrup of hypophosphites, with the newer meat preparations, will supply lacking material, while the hemorrhagic manifestations are best controlled by the fluid extract of ergot and aromatic sulphuric acid, separately or combined.

Of the importance of fresh air, cleanliness, etc. one need scarcely speak in this place.

Rickets.

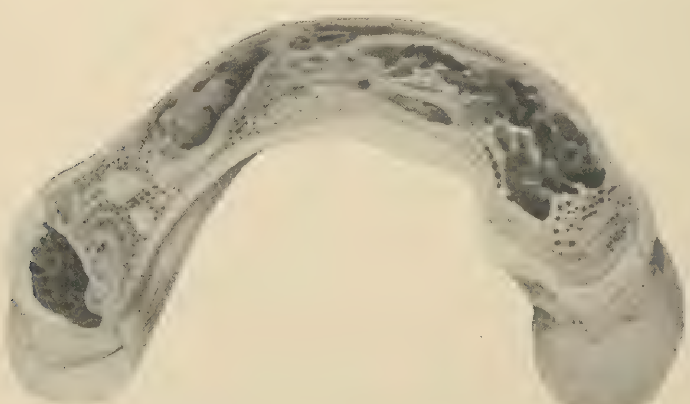
Rickets, or rachitis, is another of the diathetic conditions, in this instance not yet considered of parasitic origin, met with most commonly

in infancy and early childhood, although its resulting lesions may persist throughout life. It is characterized by nutritional disturbances and organic irregularities.

Like scurvy, rickets is a disease of mal-assimilation, but due for the most part to widely different causes. It is by no means necessarily a disease of the poorer classes, but instances of it among the wealthy and fashionable abound. These are largely due to the absurd restrictions which society imposes upon fashionable mothers during pregnancy or lactation, the result being that children are brought into the world born of those whose nutrition is bad, inheriting inability to assimilate, and perhaps after birth being condemned to artificial foods because the mothers cannot or will not nurse them. The result is a puny physical development and an utterly inadequate supply of those elements which especially go to form the bony skeleton. Thus, while the conditions predisposing to rickets abound among the poor, they are met with as well among the rich. One may say perhaps that chemically the disease is largely characterized by absence of calcium salts. While probably the most characteristic evidences of rickets are seen in the bony skeleton, they are by no means confined to it; for which reason rickets is considered here rather than in the Chapter on Diseases of the Osseous System. Another theory to account for rickets is excess of lactic acid, but this perhaps is not easily separable from the other, which accounts for it by absence of calcium salts, the one not being present to neutralize the other. Rickets is prevalent in every country, but it is perhaps seen most often in Europe, particularly often in Italy and Great Britain. The negro race is notably rachitic.

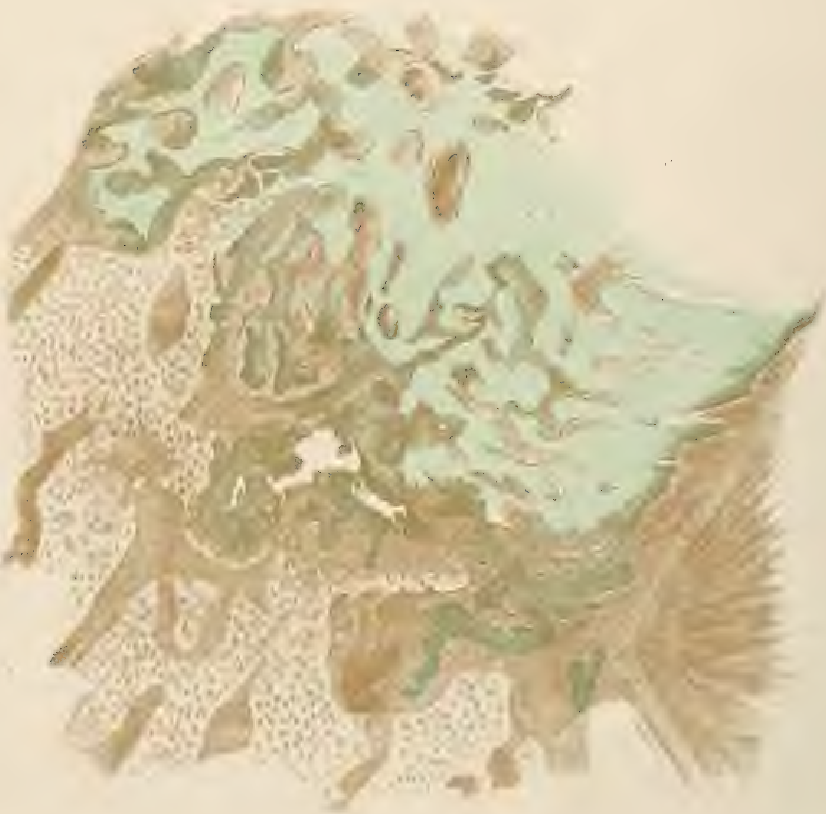
Pathology.—Rickets is spoken of as "fœtal" or "congenital" according to whether the infant presents characteristic markings at birth or whether they develop later. So far as one can see, the most marked constitutional defect is in the supply of calcium salt, which leads apparently to formation of bone which has not enough of compact tissue to make it strong. Especially along the line of junction between bone and cartilage do we see the most marked expressions of rachitic lesions. Here the cartilage is evidently actively growing, while the bone-formation proceeds with difficulty, and the proportion of vascular tissue is excessive. The result is prolongations of soft vascular into the cartilaginous tissue, by which the latter becomes more or less absorbed and *ossification is essentially interfered with.* In fact, in severe cases it may

Fig. 78.



Rachitic rib, showing characteristic changes.

PLATE X.



Congenital Pseudo-Rachitis, showing Aplasia of Cartilage; *a*, Osteo-Periosteum; *b*, Quiescent Cartilage; *c*, Periosteum penetrating between Bone and Cartilage. (Klebs.)

be entirely lacking. In consequence, at epiphyseal lines one may have a layer of osteoid tissue which is not cartilage and will not become bone. Because of its yielding nature, then, it warps under the mechanical strain to which the bones of the extremities in young children are constantly subjected.

The osseous lesions of rickets differ from those seen in osteomalacia in that in the latter the softened tissue is practically decalcified bone, while in the former case most of the affected tissue has never got so far as genuine bone-formation, but is arrested in its perverted state.

The result of rickety changes in the skeleton is a thickening of the shafts of long bones, of the outer table of flat ones, of the epiphyseal extremities of shafts and frequently a stunting of their development, so that they do not attain their normal length. The periosteum, having much to do with the development of bone, is also affected in rickets, with the result that when the changes occur, mostly subperiosteally, we get warpings and curvings of the bone-shafts, while so long as the disturbance is epiphyseal more or less abrupt curvatures and angular deformities will be produced as the result of muscle-action. So marked are the changes in some instances that it has been stated that bones may even lose three-fourths of the calcium salts which they ought to contain. When, as is the case, rachitic bones are so soft as to be easily cut with a knife, it is not strange that marked deformities occur as the result of muscular activity. (*Vide* Plate X.)

Thus, in the extremities we get *bow-legs*, *knock-knees*, *clubbing of the ends of the long bones*, bending of the neck of the femur, *flat-foot*, *club-foot*, etc.; while the clubbing of the bone-ends may be also well marked in the bones of the upper extremity, where, however, marked deformity is less common, because the upper extremity does not bear the weight of the growing body. In the skull the bones remain soft and yielding to pressure, with a tendency to return to their original membranous condition, and this is the condition comprised under the term *craniotabes rachitica*. The *fontanelles always remain open* for an undue time; the sutures are broad and membranous. The *bones of the face grow less rapidly*, giving to the face a disproportionately small size; *dentition is delayed* and the *teeth decay very easily*. The upper incisors often project far over the lower.

In the thorax we get enlargements of the sternal ends of the ribs, causing a row of nodules spoken of as *the rachitic rosary*. The ribs tend to sink in, the sternum to be protruded forward, and the deformity known as *pigeon-breast* becomes often pronounced. Curvatures of the spinal column, especially *kyphosis*, are common, and distinct degrees of *lateral curvature* are frequently begun as a rachitic deformity, to be magnified by perverted muscle-action as the child grows older. In the pelvis the innominate bones approach each other, causing the pelvic cavity to become contracted, or the sacral promontory projects too far, or in various other ways the normal pelvic diameters are so far compromised that *rachitic deformities of the pelvis* constitute the most common and most serious obstacles to normal labor in adult women, and are the most frequent cause of major obstetric operations.

While the rachitic changes in the osseous system are the most distinctive and easily recognized, numerous other organs and tissues of the body are more or less seriously compromised. *Ventricular dilatation*, leading to chronic *hydrocephalus*, is one of the common results of rachitis of the skull, which may be followed by convulsions and may terminate fatally. So, again, we get *porencephalon* and *cerebral sclerosis*. Disturbances of digestion are common in rickety children: the *liver* is sometimes decreased, sometimes much enlarged; the *spleen*, particularly, often *enlarges*, and sometimes to enormous dimensions. In various other parts of the body we get the same expressions of malnutrition as are met with in tubercular disease. Rickety children *perspire easily*, particularly at night, when the head will often be found bathed in perspiration. They are fretful and irritable as a rule, and difficult to control. A child with protuberant belly, due to enlargement of liver

and spleen, as well as to crowding up of pelvic organs, with relaxation of abdominal walls, with a contracted and distorted thorax, with the skull flattened on the top, with clubbed bone-ends, with a history of resting badly at night and sweating profusely, constitutes a clinical picture of rachitis so marked that it can be recognized at a glance. Between this picture in its worst forms and the slightest deviation from the ideal type one may meet with all degrees in manifestations of rickets in the children of the rich or the poor, while in adults one may often see evidences of that which had obtained during early childhood. In order that all these features may be made out the children should be stripped and examined from head to foot.

While rickets may be a very acute disease, it is, as a rule, chronic, and children dying essentially from this disease die rather from cerebral or other manifestations which may be regarded as in some degree accidental. *Scurvy* and other nutritive disturbances may be associated with rickets.

TREATMENT.—The treatment for the condition consists mainly in *proper nutrition*. Mother's milk is certainly preferable to any other, and should be insisted upon if possible. If feeding must be artificial, it should be in accordance with the very best precepts of modern therapeuties. Cod-liver-oil emulsions are of advantage; compound syrup of the hypophosphites is a remedy of great virtue. Very minute doses of phosphorus seem to be of value—1 milligramme *pro die*. It is a mistake to let rickety children begin to walk, or even to creep, too early. They should be kept, so far as possible, in cribs or upon the back.

The deformities due to rickets are so numerous as to constitute a large part of those to which special or orthopædic surgery is addressed. The mechanical and operative treatment of these cases will be referred to in other and appropriate parts of this work.

CHAPTER XIV.

SURGICAL ASPECTS AND SEQUELÆ OF OTHER INFECTIONS AND DISEASES.

By Roswell Park, M. D.

As the result perhaps of the conditions which, two centuries ago and more, so distinctly separated the barber-surgeons from the practitioners of medicine, there has been evolved, partly from tradition and partly from custom, an artificial and unfortunate separation of surgery from so-called internal medicine. The consequence has been a more or less deep-rooted feeling, in the minds of young practitioners especially, that medical cases were to be treated exclusively by non-operative measures, and that surgical cases could scarcely be expected to present any perplexities that were not to be solved by an operating surgeon. It has been no small part of the benefit resulting from modern teachings that these imaginary boundaries and limitations have been swept away; and one of the lessons which this text-book is intended to inculcate is that broad principles underlie disease conditions, and that one must appreciate their bearings thoroughly in order to practise either medicine or surgery successfully. In order better to inculcate this teaching I have deemed it wise to insert a chapter with the above general heading, in order to impress, so far as one may, the statement that some learn too late, that any of the co-called internal diseases may present at almost any time indications, sometimes urgent, for distinctly surgical interference. Some of the surgical sequelæ of the exanthematous and continued fevers are well known and commonly recognized: for example, *orchitis following mumps, suppurative inflammation of the middle ear after scarlatina, and bed-sores after typhus and typhoid.* These are, of course, easily recognized, but concerning many others the text-books are singularly silent.

The majority of these surgical lesions are expressions, in one form or another, of mixed or secondary infections, to which reference has been already made, and of these the majority assume the suppurative type. Of the various tissues or organs involved in these expressions of disease, the most commonly affected perhaps are the *joints*, the *bones*, and the *lymphatic tissues*, although no tissue nor organ may always escape. In time past too many of these sequelæ have been roughly grouped, as by Bonnet, for instance, among the consecutive rheumatisms, which he carefully warned us are not to be confounded with genuine rheumatisms. How often the surgeon of to-day has had to open up collections of pus in cases which were formerly almost always, and are yet too often regarded as rheumatism, the various museums and hospital records will eloquently testify. Rheumatism, as such, is one of the affections which is never followed by suppuration until some purely distinct infection occurs; and the part which suppurates is not one which has been recently involved in the true rheumatic attack. How many errors of diagnosis the vague term "rheumatism" is made to cover no one knows: let us hope that in the future such errors may be far less common than they have been in the

past. Since the *renaissance* of surgery which bacteriological study has brought about, we have at last the explanation of that for which in time past many and often absurd theories were invoked. Of the so-called non-surgical diseases which may yet be followed by distinctly surgical sequelæ I will not venture a careful list, but will simply call attention especially, as illustrative examples, to the following:

Dysentery.

Joint-complications in this disease have been recognized from the earliest times. One hundred and fifty years ago Strack expressed himself thus: "If the dysenteric poison affect only the chest, it causes asthma; if the limbs, it produces arthritis; if both, abscess." Joint-pains and swellings, with other suppurations, have been noted in several of the epidemics of this disease which have ravaged various parts of the world at different times. Post-dysenteric arthritis may assume noticeable and even pyæmic aspects, and is occasionally fatal. The bones and joints may become involved in painful and even suppurative swellings, not alone during the active stage of the disease, but during the period of convalescence; while mildness of the primary attack does not necessarily provide immunity from later complications. Here, too, as in many other instances, thrombosis of large veins or thrombo-phlebitis is also observed. When the joints are involved, it is usually in irregular order and not simultaneously. Joint-lesion does not necessarily proceed to suppuration, perhaps only to the point of œdema and fluid exudation or hydrops.

Dysenteric amœbæ have been found by Kartulis in an osteomyelitic focus in the lower jaw of an Arab.

Cholera.

Cholera is usually too rapid and too violent in its course to be followed by secondary infections. Nevertheless, Poulet reports from Val-de-Grace several instances of articular and osseous lesions, some of these characterized by mere effusion of fluid which was sometimes very thick and resembled balsam, while at other times pus was present.

Pneumonia.

Pneumonia having now taken its place as a distinct germ-disease, and the micrococcus of Fränkel and the capsule coccus of Friedländer being now well established as the active agents in the two principal forms of this disease, we need not be surprised at finding collections of pus in various other parts of the body. For the most part, the surgical sequelæ of pneumonia occur as a post-pneumonic pyarthrosis, which in time past was also considered as a rheumatic affection. These lesions are probably of embolic or, strictly speaking, of metastatic origin.

Pyæmic manifestations are noted occasionally after pneumonia, and patients even die essentially of post-pneumonic pyæmia or of terminal infections, rather than of pneumonia alone. Deep and painful bone-lesions, essentially of the type of acute infectious osteomyelitis, have also been noted; and in some of the joints involved in post-pneumonic pyarthrosis resection has been necessary because of the extensive destruction of joint disease. Abscess in the brain has also been observed, as well as a double-sided parotitis and various other lesions of this general character, while the frequency with which empyema follows pneumonia is a matter of general acceptance.

Tuberculosis.

So much has already been said about the general aspects of tubercular disease that it will be enough to simply recall here that in the course of pulmonary tuberculosis surgical expressions of the same infection may be found in various parts of the body.

Influenza, or Grippe.

Within the past few years this disease has assumed great prominence in medical literature, and not a few instances have been reported of surgical sequelæ—abscesses, purulent ear disease, pyarthrosis, bone-lesions, etc. Even necrosis has been repeatedly observed.

Although here, as in other instances, the surgical lesions by themselves do not have a peculiar type as does the original disease, nevertheless it must be borne in mind that the case of uncomplicated grippe of to-day may, a month hence, be in the hands of the surgeon for serious operation. I have had, for instance, to evacuate a litre of pus from a large subfascial abscess which made its appearance while the patient was recovering from the acute stage of this disease, while no other explanation could be afforded than a secondary pyogenic infection because of the lowered tissue-resistance produced by the primary disease. It has been also observed that patients who when attacked by grippe are in the stage of recovery from operation are much more prone to suffer from complications, often serious, than others. They manifest also a remarkable slowness in the processes of repair and cicatrization. The eye, the ear, the pleura, the pericardium, the salivary glands, and the testes do not escape in such instances as these.

Measles and Scarlatina.

The frequency with which these exanthems are followed by surgical complications has been noted by many authors. Inasmuch as the infectious agent is not yet recognized, we must probably consider their surgical sequelæ as due to secondary pyogenic infections, which are relatively very common.

Remembering what has already been said upon the principal ports of entry for disease-germs, in connection with the notable lesions of the mucous membranes and the lymphadenoid tissue of the nasopharynx which are characteristic of these two diseases, it will be readily appreciated how pyogenic organisms may secure an entrance permitting their distribution to various parts of the body, while the lowered resistance of these patients permits the pernicious activity of these germs to make itself felt when otherwise it would not be. It is notorious that surgical tuberculosis appears often as a sequel of the exanthemata, and it is in no degree straining after effect when one explains the entrance of these germs in the way above described. Consequently, in the lymphatics, in the periosteum, bones, and joint-cavities especially, and in and about the eye and ear, we very frequently find manifestations of suppurative disease. It is generally believed that these sequelæ are more likely to appear when the eruption has been incomplete. The fact that hyperplastic thickening of periosteum and neuralgic pains of the affected parts are often met with without suppuration has given, in time past, some reason for the rheumatic character which Bonnet and others have ascribed to these manifestations.

While the absence of pus takes these out of the category of pyogenic infections, it nevertheless leaves them still as surgical complications which have often to be dealt with by mechanical measures, such as orthopædic apparatus, etc.; while too frequently more or less formidable operations, as for relief of ankylosis, etc., have to be performed. Post-scarlatinal arthralgia may be explained as a local ischæmia; so may acute swelling or chronic thickening. But pus is always an expression

of infection, and cannot be otherwise regarded. Joint-distention with fluid which is not pus may even take place to the degree of producing a dislocation, and I have seen luxation of the hip from this cause. Twice I have also seen spurious ankylosis of the knees in bad position as the result of tissue-changes consecutive to scarlatina. On the other hand, the pyæmic features of such affections may be excedingly rapid. Trousseau has related the case of a girl whose wrist was already swollen and painful on the second day after an outbreak of scarlatina, while the child died upon the fifth day, all her joints being filled with greenish pus. That streptococci have much to do with scarlatina has been established by numerous investigators, though we are not yet in position to say positively that the disease is a streptococcus invasion. Nevertheless, these organisms will easily account for the pus met with in these cases, and I have repeatedly found them in post-scarlatinal lesions. Retropharyngeal abscesses and a peculiar necrosis of the alveolar process of the jaws, particularly described by Salter, are among the various serious surgical complications of scarlatina. Epiphyseal separations and purulent destruction of ribs have also been noted.

Typhoid.

Although in elaborate treatises, as by Liebermeister and Murchison, bone- and joint-complications find no mention as sequels of typhoid, they have nevertheless long been recognized by surgeons. Post-typhoid hip-dislocations have been reported by several German surgeons. Boyer observed spontaneous dislocation of both thighs after what he called "essential fever," and the general topic of spontaneous luxations subsequent to typhoid has been seriously discussed by the German Congress of Surgeons.

Those affections of joints which used to be considered rheumatic occur much less often after typhoid than after dysentery. Nevertheless, post-typhoidal arthralgia and myodynia have been recognized by several French writers. Probably not a few times patients with affected joints, supposed to be rheumatic, have later been discovered to be suffering from genuine typhoid fever, and it has been afterward recognized that the joint-lesion was merely a bizarre expression of the typhoid poisoning. The works on general practice call attention to the frequent complications of the pleural and pericardial serous membranes in this disease. They say little, however, about the implications of the articular serous membranes, though one is as easy to explain as the other. Post-typhoidal polyarticular serous arthritis has been described by more than one writer. Multiple joint-abscesses have been more rarely seen. Pus has also been known to collect, not only in the joints, but in the tendon-sheaths and bursæ. The lymph-nodes are also frequently affected, and cervical, axillary, and inguinal abscesses are not rare. Post-typhoidal pyarthrosis, as leading to spontaneous luxation, has had even a medico-legal interest, since luxation has been known to occur while raising or lifting a patient, the question of violence being subsequently brought into court. When the joint disease assumes the monoarticular form it is likely to terminate in suppuration; when polyarticular, pyarthrosis is much less common. In the pus from many of these abscesses typhoid bacilli may be recognized, but by no means in all. I have found them in a case of abscess in the abdominal wall occurring during convalescence from typhoid in a young woman. A non-suppurative but extremely painful form of periostitis is occasionally met with; and I never have seen more exquisite tenderness nor expressions of greater suffering than I met with in a case of this kind in a young lad in whom the bones of both lower extremities, of the pelvis, and the lower spine were all involved. The slightest jar upon the floor called out a cry of pain, and to minister to his ordinary wants was a most distress-

ing task. He eventually recovered without any pus-formation. Deep suppurations in bone are less often met with, but occasionally occur; even necrosis with separation of sequestra has been noted.

Thrombosis and thrombo-phlebitis are also well-known sequels of typhoid, which may lead to most unpleasant complications. Typhoid fever appears to bear a peculiar relation to the growth of bones, since it has been noticed that during its course, or during convalescence, they show an extraordinarily rapid growth in length, even to the extent of 1 mm. a day. This is probably caused by the irritation of the typhoid toxine upon the osteogenic tissue, since hyperæmic areas have, by numerous observers, been found in the bone-marrow of those dying of the disease, and bone-pains are a frequent accompaniment of the disease. Typhoid bacilli have the power of remaining latent in the tissues for considerable lengths of time after cessation of all active symptoms, and they have been found alive and capable of active growth so long as seven months after cessation of the fever. Remembering the multiple ulcers of the lymphoid tissue which characterize the intestinal lesions of typhoid, one will not find it hard to explain pyogenic or other septic infection by absorption through these open ports of entry; and the typhoid bacilli themselves, entering the circulation through these paths, may be carried to all parts of the body, and have been found in the pia —in fact, everywhere.

Diphtheria.

This also belongs to the diseases frequently complicated by lesions, aside from those of laryngeal obstruction, calling for surgical relief. Abscess occurs so frequently as to scarcely call for comment. Here, as in the cases of scarlatina, the location of the throat-lesions and the absorbing powers of the lymphadenoid tissue so completely involved will readily account for all septic or pyogenic manifestations at a distance. Multiple abscesses have been found, for instance, in the liver, the spleen, and lungs, in and around the bones—everywhere, in fact, where abscesses can form—betokening thereby a pyæmic manifestation. Infectious nephritis is also common. It is also notorious that patients recovering from diphtheria have a lowered susceptibility, as against other infections, of indefinite but considerable duration; consequently, post-diphtheritic tubercular invasions are common. Nevertheless, post-diphtheritic multiple pyarthrosis of ordinary pyogenic type has been repeatedly noted, numerous joints being involved, even the temporo-maxillary and the costo-sternal.

Other forms of septic angina, pseudo-diphtheritic, etc. are also liable to be followed by evidences of septic infection at a distance, the tonsils and any decayed teeth which may be present probably serving as paths of infection. I have seen, for instance, a case of most serious tonsillitis, where for hours we stood ready to make tracheotomy for relief of threatened suffocation, in which extensive abscesses developed about one knee and the lower part of the other leg.

Mumps.

The infectious character of this disease is not questioned to-day, although not definitely established. Orchitis, ovaritis, stomatitis, enlargement of the tonsils and spleen, and albuminuria are frequent

accompaniments of the disease, while articular and periarticular complications have been noted by several writers. Bursal abscesses and pyarthroses have also been reported. In time past these surgical complications have been spoken of as rheumatoid or rheumatic, their essential significance not being recognized until comparatively recently.

Variola.

The writers of the earlier part of this century allude frequently to the rheumatoid complications of smallpox, among which pyarthrosis seemed perhaps the most common, as certainly the most serious. The various arthropathies are the most interesting of the surgical complications of this disease. That joints become swollen, red, and painful is not infrequently noted, and that one joint after another is involved is also the usual programme.

Some have held that because the periosteum, and even the endocardium, become inflamed, this must be a rheumatism, but this will not be claimed to-day in the light of our knowledge of the infectious diseases. Necrosis with spontaneous elimination of sequestra has also been noted. Trousseau mentions that joint-inflammations following smallpox very easily take on a purulent character, but unmistakable pyæmia appears to be a rare complication. The occurrence of acute abscesses in bones has also been noted. Considering the nature of the pustules characteristic of variola, and their multiplicity, it is a source of surprise that suppurative internal complications do not occur very much oftener than appears to be the case.

Cerebro-spinal Meningitis.

It is now well established that this disease, certainly in its epidemic form, is of microbic origin. This being the case, we need not be surprised to find evidences of secondary infection, providing only that patients live long enough to develop them. Too often death occurs with such rapidity that time for secondary symptoms is scarcely offered. Nevertheless, the studies of such authors as Grisolle, Laveran, and others show that we have occasionally articular complications between the fifth and eleventh days, should life persist so long, and that these not infrequently assume the suppurative type. The larger joints are those commonly attacked, including probably those of the vertebral column.

If suppuration may occur at all in this disease, as is well known it may, there is no reason why the meningeal cavity should not be treated as is the peritoneum or any other serous cavity when involved in an acute pyogenic infection—*i. e.* opened and drained. To be sure, this is a more serious operation, because of its bony covering, than it is to open most of the other serous cavities. Nevertheless, it is as plainly indicated, and success has followed the procedure in a fair proportion of the few instances in which it has been tried. It at least is as promising as non-operative treatment, and often more so. (For a further discussion of this the reader is referred to Chapter I., Volume II.)

Infectious Endocarditis.

The individuality of this condition has been recognized only within the last thirty years, and accurately only within ten. That it deserves the characterization of "malignant" often given to it is well known. It is, in fact, an infectious disease with a special localization in the heart, the term *cardiac typhus*, given to it by some, being very expressive.

Although so apparently spontaneous, it is itself, in fact, usually a secondary lesion, perhaps sometimes a primary infection. When we consider the peculiar location of the disease, we shall have no difficulty in appreciating the readiness with which metastatic complications may arise. The arthritic manifestations, too, often assume a pyæmic character, and even at the beginning of the affection, as Trousseau pointed out, there are frequently severe joint-pains. Abscesses may form very rapidly, while around the joints there occurs oftentimes diffuse œdema, which is simply another expression of the intensity of the disturbance. The infectious character of these complications should be kept distinct from the category of multiple hemorrhages and articular effusions of purely serous character which accompany the so-called non-septic form of endocarditis—kept distinct, at least, until there is more argument for its infectious character than we now have.

Dental Caries.

Nearly one hundred species of micro-organisms from the mouth have been studied and identified by W. D. Miller, who has clearly established that dental caries is due to the specific action of some of these parasites, which, gaining entrance into the dental tubules, determine fermentation and acid-production, with erosion of the dental structure of the teeth and an increase in softening and destruction. In this way the teeth, as already indicated in Chapter III., become wide-open paths of infection for germs which may travel but a short distance, causing only local disturbance, or which may be carried to other points about the head, producing disturbance in the antrum, in the neighboring bones, in the middle ear, and not infrequently in the brain. Abscess in the brain has been distinctly traced to caries of the teeth. Tubercular infection is also common through this channel, and its most common expression is probably the invasion of the cervical lymphatics, superficial and deep, constituting those lymphatic tumors of the neck formerly known as scrofulous, with their disastrous train of adhesions, suppuration, erosion, etc.

Syphilis and Gonorrhœa.

These are surgical affections whose secondary complications in the way of abscesses, infarcts, tumors, etc. will be dealt with in other parts of this work. It will simply be well to group all of these infections—those just mentioned—along with anthrax, glanders, etc. into a class of infections which may be followed by tardy or very late surgical sequelæ which may call for more or less radical operation. In the case of gonorrhœa this is seen best, perhaps, in the so-called *pus-tubes* of the female pelvis, which often call for operations years after the date of the primary invasion.

The Puerperal State.

This is seldom followed by surgical sequelæ, save in the instance of mechanical lacerations demanding plastic repair, or of septic infections, which, when life is saved, sometimes lead to disastrous, though remote,

consequences. Puerperal septicæmia is in no respect different, pathologically speaking, from septicæmia due to any other presumably streptococcus invasion; and the predilection which streptococci manifest for serous membranes, and especially joints, is well known. Consequently, after puerperal fever one may meet with articular or periarticular abscesses, affections of tendon-sheaths, lymphatics, etc., or the complication may assume a different type, the veins and their contents being mainly involved, with thrombosis, infarct, etc. for its immediate results. The possible outcome of these various lesions will be appreciated if one simply reflect upon the known course of the blood and bear in mind the facts stated in Chapter II.

As stated at the outset, it was intended to make this chapter suggestive rather than complete. In summarizing it would be well, probably, to say that there is probably no disease of known or suspected germ-origin which may not be followed by disastrous or unexpected surgical complications, while even those degenerative changes for which as yet no theory of parasitism has been invoked are followed by conditions, often painful in the extreme and crippling, which may call for most serious surgical measures. *In other words, the surgical complications of any so-called non-surgical disease may loom up at any moment in any case, and may even tax to the utmost the resources of a surgeon, who should be promptly summoned in the unwillingness of the general practitioner to act as such.* Surgical sequelæ are always unfortunate, but are always most so when unfortunate delay in their recognition or in summoning special help has been permitted to occur.

CHAPTER XV.

POISONING BY ANIMALS AND PLANTS.

By Roswell Park, M. D.

Certain poisons or deleterious substances are introduced in various ways into the human system from without, some of which produce only symptoms of moderate intensity, while others are quickly fatal. Thus, it is authentically stated that in India many thousands of individuals lose their lives every year as the result of the bites of poisonous snakes. Nothing approaching such injuries in frequency or intensity can be found in any other part of the world. Animal poisons may be introduced by animals of many species. The poison of hydrophobia has been already sufficiently described. The bites of the mammalia may be serious and may be followed by septic symptoms, but they are not regarded as due to any special toxine secreted by the animal. A number of reptiles, however, possess special *poison-glands* which, for the most part, are connected with a tooth on either side of the upper jaw which is canaliculated and serves as a duct through which the poison is injected when the animal inflicts its bite.

The principal poisonous serpents in North America are the *rattlesnakes*—of which there are several species, usually placed at eighteen—the *copperheads*, the *moccasins* and the *vipers*. Some of these have movable poison-fangs, some fixed. In other parts of the world others equally or even more poisonous are known.

The poison-gland is analogous to the parotid in location and structure. The duct which runs through it is so dilated as to contain a small amount of the peculiar poison. The amount of poison contained in these reservoirs varies from eight to twelve minims, and is secreted somewhat slowly. It seems to be, in some cases at least, a *glucoside;* in others, a *toxalbumen.* It is capable of being preserved either dry or in alcohol or glycerin. The active poisonous principle seems to pertain to a *globulin* or to a *peptone.* Almost all of these venoms are innocuous if swallowed, and like septic infections seem inoculable only through the tissues and the circulating fluids. According to Mitchell, the venom of the rattlesnake renders the blood incoagulable, paralyzes the walls of the capillaries, and facilitates escape of leucocytes into the tissues, thus making actual hemorrhagic swelling occur easily; while the red corpuscles rapidly lose shape and fuse together into irregular masses and their hæmoglobin is dissolved or disappears. This poison seems to paralyze both the respiratory centre and the heart. Cobra-poison, not containing globulin, at least to such extent, does not produce the rapid changes of rattlesnake poison.

Symptoms.—A snake-bite is like a hypodermic injection of a deadly poison, and symptoms set in usually very promptly. These are both local and general. There is more or less local pain, with swelling and discoloration, these being due to effusion of blood. They increase in intensity, and are followed by vesication and necrosis of tissues—*i. e.* gangrene—if the patient survive long enough. Constitutional symp-

toms are not long delayed, and are characterized by severe prostration, including cold, clammy sweat, feeble and rapid pulse, irregular respiration, etc. When patients die, they die usually in collapse. The pathological changes are not sufficiently well marked or characteristic to detain us here.

TREATMENT.—Treatment of snake-bite must be most prompt if it is to be successful. It should consist of the promptest possible incision and drainage of blood from the part, with application of a tight ligature or tourniquet above the bite, in order to prevent diffusion into the rest of the body by means of the returning blood and lymph. Bleeding should be facilitated by cups or by sucking of the wound. If there be any known antidote to snake-poison, it consists of potassium permanganate or calcium hypochlorite (chloride of lime), which may be applied locally in solutions, the former strong enough to have a very marked color and capable of producing local irritation (1 per cent.). Along with these local measures, constitutional stimulation should be most active by means of both volatile and other stimulants. There is a popular fallacy in favor of inducing alcoholic intoxication. To do this is undoubtedly a mistake. Nevertheless, alcohol may be given freely, dosage being limited not by amount, but by effect. Strychnia, digitalis, atropia, etc. will often prove serviceable. The tourniquet should be after two or three hours very gradually released, while one should be ready to antidote the poison which may thus enter the system with the necessary doses of stimulants above mentioned. Even so much strychnia as half a grain may be administered in divided doses with happy effect, it being apparently, in large measure, a true antidote to the snake-venom. There is much reason from recent experimentation to expect benefit from a serum-therapy—*i. e.* by injection of serum from immunized animals who have been fortified by increasing doses of the snake-poison. In this country such treatment, however, will be called for so seldom that there is not the hopeful outlook for the serum-therapy of snake-bite that there is in India.

A large lizard found in the southwestern part of this country and in Northern Mexico, known as the **Gila monster** (*Heloderma suspectum*), is generally credited with being a poisonous animal. The probability is that the bite is fatal to some of the lower animals and may produce more or less serious disturbance in man. Nevertheless, there is little real evidence that this is to be considered in the same category with the venomous serpents above mentioned.

Certain species of **spiders** are venomous, the *tarantula* being the best known. Certain **scorpions** also inflict poisonous stings, and *centipedes* and other animals occasion at least serious local disturbance by bites or stings. These insects and animals seldom attack unless irritated or disturbed. Tarantula-bites are occasionally inflicted in the Northern States by spiders which have concealed themselves in shipments of fruit, bunches of bananas being especially likely to be their hiding-places. The injuries inflicted by these animal organisms cause local pain, considerable swelling, with remote effects on the nervous system, prostration, restlessness, etc. They are seldom fatal, but may cause exceeding great annoyance and even serious disturbance. These cases are to be treated in the same way as bites of poisonous serpents, adapting the

measures and the energy of the treatment to the severity of the symptoms.

Wasps, hornets, and **bees** are capable of inflicting severe stings, while smaller and more domestic insects, like *mosquitoes, bedbugs,* etc., inflict minute injuries, which, nevertheless, sometimes occasion excessive annoyance. Their sting is followed by pain, burning sensation, sometimes intense itching, and more or less swelling. Enough poison is deposited to produce local vasomotor paralysis, as the result of which wheals resembling those of urticaria, or more extensive swellings, quickly result. If the sting of an insect has been broken off in ridding one's self of it, it may remain and intensify the disturbance. Two or three injuries of this kind create at most local disturbance, but there are numerous instances on record where men and animals have been stung to death when attacked by swarms of these little enemies of our race, death apparently being due to intensification of effect owing to increased dosage of poison. If a sting occur upon loose tissues, like the eyelid, or upon the tongue or lips, swelling and suffering may be extreme. If symptoms of depression present, they must be combated by stimulants, diffusible or other, and by hypodermic medication *pro re nata.* Local discomfort may be alleviated by ice, by menthol, by chloral-camphor, etc.[1]

The **arrow-poison** of various Indian and savage tribes is a composition of very variable and usually unknown nature. It is compounded, for the most part, from vegetable substances, and, if one may judge from the specimens of *curare* sold by importing houses, their strength must be most unreliable.

While some of these preparations are made by the natives from species of Strychnos growing in the northern part of South America, this tree certainly is not in universal use for this purpose: in the East Indies they are made from a species of Upas (the deadly Upas of song and story). Some of the poisoned arrows of certain tribes are dipped in putrefying blood. A wound made by these is not necessarily promptly fatal, but would tend to kill by setting up septic disturbance. The vegetable poisons have, for the most part, the property of paralyzing the motor nerves and the circulation, to such an extent even that death may occur within a few moments after injury. All of these poisons are innocuous when swallowed, and game killed by their agency may be eaten with impunity. Arrow-poison of the vegetable variety which is not fatal within a few hours may be recovered from if only stimulation be vigorous enough. Artificial respiration is a factor of very great importance in keeping such patients alive.

Many of the lower forms of marine animals are capable of inflicting stings by their rays, or minute injuries in other ways, which give rise to great temporary annoyance. The *stinging nettle,* etc. are instances of this kind. The lesions produced in this way partake of the nature of a more or less acute dermatitis.

In the vegetable kingdom there is one species of plant which is capable in certain instances of producing the most intense dermatitis. I refer here to the so-called **poison-ivy** (*Rhus toxicodendron,* etc.). Not all individuals are susceptible to this poison—least so those of thick skin and dark hair. It is rather those of blond type and thin skin who seem most liable to its irritation.

[1] Oil of lavender is a pleasant means of local protection against mosquitoes, etc. Oil of tar is also in common use. A mixture of equal parts of camphor and chloral, with menthol dissolved in the mixture (camphor and chloral when mixed without other ingredients quickly form a dense fluid like glycerin), gives great local relief from the itching and pain of insect-bites.

The active agent is *toxicodendric acid*, and it is capable of setting up the most intense irritation of the eczematous type, with a large amount of hyperæmia and œdema, especially of soft tissues. Thus, when the face is involved the eyelids become so puffed as to make it almost impossible to separate them for purposes of vision. *Ivy-poisoning* comes practically always from contact with the plant, which grows in various parts of the country, and with which one may come in contact in most unexpected places. Symptoms supervene usually within twenty-four hours, probably much less, and in well-marked cases do not subside for three or four days. The itching is almost intolerable, and is best combated by strong alkaline solutions or brine. A very dilute bromine solution is also of very great benefit, but is not always ready at hand in instances of ivy-poisoning in the woods. Salt and soda, however, are nearly always at hand, and can be used with great relief in pretty strong solutions. Vigorous catharsis will also help, and hypodermic injections may be necessary for the enjoyment of sleep.

Certain other species of *sumach* will also produce similar symptoms, usually less severe, in a comparatively small proportion of susceptible individuals. This is true in milder degree of certain species of the genus Cypripedium.

CHAPTER XVI.

ACUTE INTOXICATIONS, INCLUDING DELIRIUM TREMENS.

By Roswell Park, M.D.

Delirium tremens as an expression of acute or subacute alcoholic poisoning is in no essential degree a surgical condition. Nevertheless, it so notably and often so disastrously complicates surgical cases that it is necessary to take it into account in this place. This form of toxic delirium may occur while the individual is still drinking hard, or not until several days have elapsed after active drinking has ceased. It is precipitated in many cases, where otherwise it would simply remain imminent, by surgical injuries and operations. In an individual in whom it is feared, we should become apprehensive in proportion as the muscular system becomes unsteady and tremulous, the mind disturbed, and the individual sleepless. It comes on usually with anxiety of countenance, with more or less hallucination, which is often of a frightful nature, with fright at trifling incidents, with restlessness, and with curious perversions of sensation, the patient hearing imaginary noises, seeing visions of everything that is disagreeable, and tortured by sensations of insects, reptiles, etc. upon his person. Insomnia deepens perhaps into absolute terror, and there is refusal to take food. Patients become rapidly reduced in strength, and are absolutely irresponsible for their actions, with respiration irregular, surface bathed in perspiration, urine scanty, bowels sluggish, tongue tremulous and furred, and often such disturbance of the stomach that there is rejection of all kinds of food. Should the case go on from bad to worse, prostration increases, tormenting hallucinations may increase, the patient remains either furious or stupid, agitation and muscular tremor are constant, the urine becomes nearly completely suppressed, and death, perhaps preceded by convulsions, finally terminates the case. Should the case not prove so serious, there is usually abatement of illusions and hallucinations; the patient begins to sleep restfully, although perhaps only for a short time; gastric irritability subsides; nutrition is resumed; pulse and respiration become more regular; reason returns to the disturbed mind; and amelioration follows in every respect.

Patients in a well-marked condition of delirium tremens become often so uncontrollable and so lost to sensation of pain that it may be practically impossible to enforce the physiological rest which their surgical condition demands. The restraining sheet will answer for general purposes, but the strait-jacket, and even the most carefully applied plaster splint or mechanical restraint, will not always be sufficient to carry out the indication. Ingenuity may be taxed beyond its limit to

enforce the needed rest, for patients will tear off bandages and injure themselves in various ways.

TREATMENT.—The *local indications*, as just expressed, are in the direction of *physiological rest* if it can possibly be enforced. *Constitutionally*, the indications are in two directions: First, *to keep up nutrition and excretion;* secondly, *to properly medicate.* Nutrition is difficult unless excretion be maintained. Hot-air baths, laxative enemata, preferably of cold water, when necessary, and administration of a fluid and easily assimilable diet are measures of the utmost importance. Should the case present features of an acute alcoholic gastritis, stomach-feeding may be altogether abandoned and the rectum utilized for this purpose. *Medication* must consist mostly of stimulants, with such sedatives, laxatives, diuretics, etc. as may be necessary. Whatever may be the general wisdom of the course, it is probable that in surgical cases it is not wise to abruptly deprive these patients of the alcohol which they have so abused. Consequently, it is well in many instances to continue a mild degree of alcoholic stimulation, at least for a time, letting them down, as it were, by the easiest possible stages. Two stimulants rank higher than all others put together as substitutes for alcohol, and in some degree antidotes to its effect. These are *strychnia* and *digitalis.* The former should be given preferably subcutaneously; the latter by the stomach if tolerated; otherwise, by the rectum or beneath the skin. My own preference for the use of digitalis is in the direction of large and few doses. I have not hesitated in many instances to give 15 c.c. of ordinary tincture, repeated once or twice at intervals of a few hours, and then to discontinue it. The effect is both to brace up the heart and to equalize the circulation, while at the same time it acts as a most efficient diuretic; and I never have had occasion to regret such doses; on the other hand, I have often seen them do great good.

Of the sedatives, bromides, chloral, and remedies of that class are those most often resorted to, and must be given in doses sufficient to meet the indication. One should remember, however, that they are all more or less depressant, and that stimulation by strychnia, etc. is necessary even while they are being administered, in spite of the apparent physiological antagonism between them. Occasionally nothing will take the place of opium, best given in the shape of morphia introduced beneath the skin. Whatever may be one's tastes or preferences for drugs under ordinary circumstances, he can but feel that in serious surgical cases complicated by delirium tremens the first indication is toward the surgical lesion, and preferences, past methods, etc. must all be secondary to enforcing such quietude as shall permit repair of injury. The first indication, then, in most of these instances is in the direction of ensuring rest and sleep, even at the expense of inconvenience or misfortune in other directions. I write this with a full realizing sense of its significance, yet with positive conviction as to its truth.

Entirely distinct from the forms of poisoning and of toxæmia already considered, and yet sufficiently allied to the caption of this chapter to require mention here, are certain other forms of toxæmia whose brief consideration is indispensable at this time and place. Of these I will first speak of—

TRAUMATIC OR POST-OPERATIVE MANIA.

This it would be difficult to distinguish from a form of mania universally recognized and known as *puerperal mania*, the two conditions

being, I take it, essentially similar. Regarding these cases from a surgeon's standpoint, and carefully avoiding any attempt at minute explanation of the phenomena, I would only say that such cases are met with in the practice of operating surgeons, as in the experience of obstetricians, presenting themselves either as mild forms of harmless mental aberration, or assuming almost any of the types of insanity as made out and classified by experts in that subject. From the mildest mental alienation, then, up to furious and even homicidal or suicidal mania, one may meet with all degrees of departure from the normal standard.

I think it is generally conceded that these cases are to be viewed as indicating a toxæmic condition whose special manifestations concern the brain and mental activities of the patient. They are of vital importance to the surgeon, however, because sometimes in these conditions his most earnest and intelligent efforts are interrupted or rendered futile by the still greater emergency which may exist of controlling a patient and keeping him even from committing suicide. Undoubtedly, in some cases these toxic conditions are due to drugs which have been used, among which *iodoform* is best known to produce such effects. The alcoholic forms have already been spoken of under Delirium Tremens, while yet other disturbed mental conditions are the immediate or remote consequence of administration of such drugs as *chloral*, *opium*, etc. Nevertheless, the fact remains that in certain instances the symptoms cannot be referred to any drug save possibly the *anæsthetic* which may have been administered for the performance of a severe operation. In my own experience, leaving out of consideration patients who were more or less addicted to alcohol, I have seen traumatic mania in more or less mild form more often in women after breast-amputations than in any other class of cases. Usually here it has assumed a melancholic type, and has called for little or no attempt at repression or restraint. I have been led to regard these cases, when not due to drugs, as apparently due to interference with the natural metabolism of the tissues of the body, probably because of interference with excretion; and I have noted that these cases occur most often in individuals whose excretion is habitually poor. This should be regarded as another reason for careful preparation of patients by the means already considered in Chapter VI., on Auto-infections. But when a patient shortly after a severe operation develops a mania of this form and becomes violent or intractable, then almost every other consideration must yield to the necessity for restraint and, so far as may be, ensuring physiological rest, for which purpose I hold it wise and life-saving to subordinate every other consideration save nutrition and excretion to this purpose, and to give whatever strong anodyne or hypnotic may be called for, in order to achieve this primary purpose. It is often found, however, that a vigorous purgative or a series of hot-air baths, or other means by which elimination is furthered, will give a better ultimate soothing effect than will any of the " drugs which enslave."

With little children who become more or less delirious, especially during sleep, after even trifling accidents, a mild manifestation of this condition need excite but little surprise. It is rather with adults in the later decades of life, with more or less sclerosed arteries and faulty excretion, that one feels most apprehension; and some of these cases are those which call even for stimulants rather than for sedatives. No succinct directions can be given which shall be universally applicable, but every such case must be treated upon its merits.

Toxic Antiseptics.

As stated above, it is generally recognized that in people perhaps of peculiar idiosyncrasies the administration of certain drugs ordinarily considered harmless is followed by more or less toxic symptoms. Obviously, if this were universally the case, or even in the majority of instances, the use of these drugs would speedily be abandoned. As it is, it is well to at least have in mind the consequences which are

occasionally known to ensue, and perhaps to weigh in every case the chances as to whether it be worth while to use a given substance of known occasional toxic power as against another which is not known to possess it.

Of the less active antiseptic agents, there is, for example, **boric acid**, ordinarily considered absolutely innocuous, yet which is known rarely to cause intestinal disturbance, while in at least one instance serious toxic effects followed its use. **Naphthalin** also, ordinarily considered as harmless, will sometimes produce vertigo or vasomotor symptoms, especially when administered internally. So many of the antiseptic materials used are more or less irritating to the skin that such local expressions as *eczema*, etc. provoke very little comment except on the part of the patients, whose comfort is sometimes temporarily very much disturbed by their action. Yet, inasmuch as it is the patients' welfare which we ordinarily seek, we must remember that the drug-eczema produced by **corrosive sublimate**, much more rarely by other antiseptics, which may so disturb a patient as to prevent sleep and make him irritable and particularly restless, is undoing very much of the good which we have sought to do him, because it is interfering with one of the first essentials of ideal wound-healing—*i. e.* physiological rest.

Iodine, by itself or in certain combinations, is a drug whose activity should never be forgotten. Applied upon the surface, it ordinarily tans the skin, and, aside from being objectionable, does no good. Injected in solutions of varying strength, as it has been in times past more than at present, into serous cavities (for example, hydroceles, etc.), it occasionally gives rise to symptoms which may even be alarming. Fatal poisoning following its injection into an ovarian cyst has been reported, and I have seen alarming symptoms produced by injection of the ordinary solution into a hydrocele sac. Much of the virtue ordinarily ascribed to **iodoform** is supposititiously credited to the liberation of free iodine by its decomposition. Whether or not this be true, it is certain that iodoform is one of the most frequently toxic of the antiseptic agents in ordinary use. In mild cases it produces headache, restlessness, wakefulness, and often a distinct taste of iodoform in the mouth. In more pronounced degrees of poisoning there is fever, with often mental derangement which may amount to delirium or even to acute mania, and may cause well-founded suspicion of meningitis. Death has repeatedly occurred, from syncope or in coma, after its use.

Carbolic acid produces unpleasant effects, both upon patient and operator, or with whomsoever it may come in contact. Aside from its local effect upon the skin, which is most unpleasant, but which usually passes away within a few hours, it seems to affect especially the kidneys, causing often temporary albuminuria with discolored urine, deranged secretion, and sometimes much more acute forms of disturbance, similar to those met with after its internal use. Carbolic poisoning was met with most frequently during the era when Lister's original directions were scrupulously followed, and at a time before we learned that it is much better to remove dirt than to try to antagonize its action. Certain eminent operating surgeons were even compelled to discontinue its use because of its unpleasant effect upon themselves as well as upon their patients.

Finally, of all the powerful antiseptic agents in common use, the most active are the soluble preparations of **mercury**, ordinarily **corrosive sublimate**, in solutions of varying strength, which are used for irrigation, douching, etc. and for preparation of dressings. Aside from an intense and even serious eczema which may follow its local use, one may meet with any or all of the expressions of mercurial poisoning after using it, particularly on certain individuals of peculiar susceptibility to this drug. Salivation, intestinal irritation, and all other well-known phenomena of mercurial poisoning have been occasionally produced, with the result that the solutions and preparations of corrosive sublimate now used are much weaker than those which were used at first, and that in many instances where it is desired to avail one's self of its properties we at the same time protect the area involved against toxic activities by dusting with some standard sterilized powder or by anointing it with some sterilized ointment which shall protect the skin, while at the same time permitting the dressings to be applied where they may best absorb wound-discharges.

PART III.

SURGICAL PRINCIPLES AND METHODS AND MINOR PROCEDURES.

CHAPTER XVII.

CONTROL OF HEMORRHAGE; ABSTRACTION OF BLOOD; PARACENTESIS; COUNTER-IRRITATION.

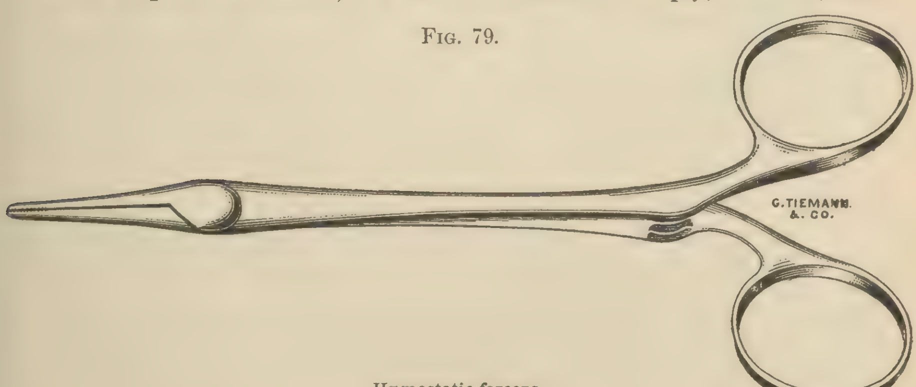
BY JOHN PARMENTER, M. D.

CONTROL OF HEMORRHAGE.

THE methods of controlling hemorrhage are many, and vary according to the nature of the hemorrhage, the situation of the vessels concerned, etc. The subject will be considered in a general sense only in this place. We may divide our measures for the control of hemorrhage into Temporary and Permanent.

I. Temporary Measures.—Among the recognized temporary expedients are (*a*) *Digital compression*, which implies the use of the finger or thumb applied over the bleeding point or over the vessel at some accessible place in its continuity. The amount of force required for all vessels, provided they are situated superficially, is surprisingly little. (More force is required for arteries than veins, of course, and also where a large muscle-covering exists without underlying bone against which to press the vessel.) When the vessels lie deeply, however, this

FIG. 79.



Hæmostatic forceps.

method is too tiring and inexact to be depended upon. Furthermore, long-continued pressure may endanger the vitality of the adjacent tissues. This danger and that of the conversion of an open into a con-

cealed hemorrhage constitute two sequelæ resulting from injudicious pressure which should always be avoided.

(*b*) *Hæmostatic Forceps.*—These serve a double use—to crush the vessel (in case of arteries) and to differentiate it from the adjacent tissues prior to torsion or the application of a ligature. It has bluntly serrated ends which easily catch and crush the vessel. Forceps are of various forms and sizes. For brain and intestinal work the hæmostatic used in Johns Hopkins Hospital and shown in Fig. 79 is especially useful because of its delicate but firm ends. For small arteries forceps usually effect permanent closure after a few minutes' application. Even the largest vessels may be closed if the pressure continues sufficiently long. In using hæmostatic forceps great care should be employed not to include any tissue excepting the vessel itself. Local necrosis is often caused by the too prolonged application to too much tissue, and doubtless frequently leads indirectly, if not directly, to suppuration in otherwise aseptic wounds. In removing the forceps it should not be made to drag upon the vessel, and should be slowly removed in order not to disturb the clot already formed.

(*c*) *Tourniquets.*—Of these the commonest, cheapest, and most generally useful is the Esmarch tourniquet, which is a piece of $\frac{3}{4}$-inch rubber tubing about $1\frac{1}{2}$ to 2 feet long, with a hook at each end. A simple rubber bandage does equally well. Where neither is obtainable a handkerchief may be bound around the part and tightly twisted with any kind of stick (cane, umbrella, etc.). As a means of controlling hemorrhage tourniquets possess certain elements of danger. If applied too long, at injudicious places, such results as *paralysis of important nerves*, sloughing, great oozing of serum from the wound, and much after-pain may result. They are therefore to be used with caution, and dispensed with as soon as the vessel can be isolated and closed.

FIG. 80.

Illustrating forced flexion for control of hemorrhage.

(*d*) *Forced Flexion.*—In suitable cases pressure can be made by putting a joint, such as the knee or elbow, in a position of forced flexion with immobilization, as shown in Fig. 80.

II. **Permanent Measures.**—(*a*) *Ligation.*—This is done by tying the vessel with some form of ligature (catgut, silk, kangaroo-tendon, etc.). The ligature may be applied at the open end of a vessel or in its continuity. Applied with moderate force, the middle and inner coats are cut through and curl up, although this is not necessary for the obliteration of the vessel.

The only object in using force sufficient to destroy the inner coats is to ensure so firm a hold upon the vessel as to prevent its slipping off. An internal clot forms, which reaches usually to the next highest branch, organization begins, and the ligated parts become a mass of cicatricial tissue. All in all, ligation is the

simplest, safest, and best method of controlling hemorrhage. Some substitutes for ligation may be mentioned here: they are *torsion* and *deep suturing*.

Torsion is effected in two ways: In small vessels it suffices to catch the end with a hæmostatic forceps and twist it around several times, stopping short of severing the twisted from the main portion. When dealing with larger vessels it is better to seize them near the end (one-third of an inch), with one hæmostatic forceps applied at right angles to the axis, and, having secured this firmly, to then twist the distal portion as above described (four or five complete turns usually suffice). This method is applicable to vessels as large as the femoral, and has the advantage

FIG. 81.

Obliteration of artery following ligation.

of enabling us to dispense with ligatures. The method is peculiarily valuable in plastic surgery and where scar is to be avoided.

Deep suturing (*ligature en masse*) consists in passing a ligature through the tissues around a vessel by means of a needle whose points of entrance and emergence are near to each other. The method is indicated in cases where the end of the vessel cannot be caught up, as occurs in certain wounds or in dense, unyielding tissues.

(*b*) *Pressure.*—This may be effected by long-continued digital pressure or by leaving a hæmostatic forceps clamped upon the vessel for a period of from twelve to forty-eight hours according to its size and tone, and by the use of gauze or other form of dressing. It is most applicable in regions where other means for arresting hemorrhage cannot readily be employed; that is, in the rectum, vagina, nose, medullary canal, socket of a tooth, wounds of the deep palmar or plantar arch, etc. The coaptation of the edges of a wound by sutures is another method of applying pressure, and is especially useful where the skin is vascular, as in the scalp and scrotum.

(*c*) *Styptics.*—These are chemical agents which arrest hemorrhage by inducing coagulation of the blood. Chief among these are persulphate and perchloride of iron, powdered alum, tannin, gallic acid, nitrate of silver, vinegar, cocaine, chloroform and water (one drachm to the pint), turpentine, antipyrine (5 to 20 per cent. solution), Park's mixture of antipyrine and tannin, solutions of each, of 15 per cent. strength, mixed. If too strong, styptics easily cause necrosis and sloughing of the tissues, and thus prevent primary union.

Styptic cotton is a convenient and useful form in which to induce hæmostasis. It is simply cotton dipped in a solution of the perchloride of iron. To get the best results from styptics, the wound should be carefully dried and the agent employed applied immediately to the bleeding point with sufficient pressure to control the hemorrhage. This should be kept up for two or three minutes. Styptics are often inefficient from non-observance of the above rules, the clot being too small and non-adherent to the walls about the opening to prevent its being washed away by the current of blood.

(*d*) *Heat.*—This may be applied in the form of water at the temperature of 120° to 150° F. or by means of the actual cautery. Hot-water irrigation is of great value upon extensive raw surfaces or in cavities which ooze. The actual cautery, of which the Paquelin is the best and most commonly employed, should be used at a dull-red heat and applied for a few moments to the bleeding point. It is a powerful hæmostatic. It checks hemorrhage, either by forming an aseptic eschar at the end of the vessel or causing the end to curl up and invert, thus finally closing the vessel. A bright-red or white heat is not hæmostatic in action. An iron heated to dull red or the galvano-cautery may be used in place of the Paquelin.

(*e*) *Cold.*—In the form of exposure to air, ice-water, or ice cold has long been used for checking hemorrhage. It causes contraction of the muscular coat, and therefore acts more promptly and effectually in arterial than in venous bleeding. The exposure of an amputation-stump to air set in motion by a fan quickly causes the surface to become dry and glazed over.

(*f*) *Elevation.*—If the upper or lower limb be held in a vertical position for sixty to ninety seconds and a tourniquet applied, we find that we have rendered the part almost bloodless; so also when hemorrhage is occurring elevation quickly lessens or stops the oozing from veins and capillaries. This is so well recognized that elevation of an amputated stump for the first few hours after operation is almost a routine practice.

(*g*) *Acupressure*, *acufilopressure*, and *acutorsion* are now rarely employed. Occasionally the one or the other method may be useful. Acupressure consists in passing a long needle through the soft parts in such a manner as to compress the vessel beneath it. When, in addition, we bind a ligature about the projecting ends of the needle, the procedure is called acufilopressure. Acutorsion consists in drawing out and transfixing with a needle the end of the vessel. The needle is then given a half or complete turn, when clot-formation occurs and hemorrhage is checked.

Abstraction of Blood.

Blood may be withdrawn from the body in various ways. In whatever form accomplished, there can be no doubt of the value of such a therapeutic agency in properly-selected cases (*vide*, *e. g.*, Chapter V.), and it is to be regretted that such simple and direct measures should have been supplanted by much less effective and more depressing medicinal means. The methods by which blood may be abstracted include *venesection*, *arteriotomy*, *scarification*, *cupping*, and *leeches*.

(1) **Venesection, or Phlebotomy.**—This consists in opening a vein, preferably the median basilic, although the median cephalic may be selected, and, where cerebral inflammation or apoplexy exists, the external jugular is often chosen. It should be borne in mind that the

median basilic vein crosses the brachial artery, being separated from it at this point by the thin aponeurosis of the biceps. In fat persons, where an excessive amount of fat covers the veins, venesection may be difficult. A bright light or reflector may be advantageously employed in such cases, the veins revealing their situation by their shadow. The opening into the vein should be made either above or below this point, the artery having been first identified by its pulsations.

Venesection is usually done as follows: The elbow having been previously rendered aseptic, a bandage is applied about the middle of the humerus sufficiently tight to retard the venous return, but to leave the radial pulse quite perceptible. The arm is allowed to hang down and the fingers given some object like a roller bandage to grasp, to better fill the vein. In a few seconds the vein becomes quite prominent, when an oblique incision may be made through the skin and wall of the vein, or, what is better, a bistoury may be thrust under the vein and a cut made outward. The opening in the skin should be generous to avoid subsequent infiltration. The blood should be allowed to flow until the pulse becomes soft and slow. The amount necessary to produce this effect varies with the individual, but in general it averages between eight and twenty ounces. Should the flow become too slow before the desired effect has been produced, it may be hastened by having the patient alternately close and open his hand and tightly squeezing whatever object he may be holding. The muscular contraction induced increases the flow. When sufficient blood has been abstracted, the encircling bandage should be removed and antiseptic dressings applied with moderate pressure. The antiseptic management of venesection is highly important, as *bent-arm*, due to suppurative cellulitis and suppurative thrombosis, followed by fatal pyæmia, has occurred not infrequently.

(2) **Arteriotomy.**—This procedure may be used where rapidity is necessary. The temporal artery is usually chosen because of its superficial situation, convenient size, and the ease with which the bleeding from it can be controlled by pressure. Its exact position may be determined by its pulsation, which can be readily felt, and in some individuals seen. The artery should not be entirely cut through to secure the best flow, although complete division is sufficiently effective. If only partial section of the artery has been made, when the bleeding has been completed the vessel should be cut entirely through and firm antiseptic dressings applied.

(3) **Scarification.**—This is performed by making several small cuts or punctures in the affected part, through which the blood will exude more or less vigorously according to circumstances. Where applicable, heat to the part and the dependent position will promote exudation of blood.

The method is safe and of genuine value, and in cases of threatening abscess, especially of the tonsils, gums, etc., and in acute inflammation of the tongue and epiglottis, it always produces a happy effect. After the blood has ceased flowing the scarified surface may be further utilized for the application of antiseptic and antiphlogistic ointments, which are much more readily absorbed from such a surface than through the intact skin.

(4) **Cupping.**—This may be either *dry* or *wet*. In *dry cupping* the blood is simply drawn to the surface, and thus, in the strict sense of the word, is not abstracted. It is, however, taken from the congested part, its effect upon which is virtually the same as though the blood was removed from the body.

Dry cupping is effected by using a cupping-glass or tumbler, the interior of which has been previously heated with an alcohol lamp or a piece of burning paper, or, better still, by rinsing one or two teaspoonfuls of alcohol around the

sides of a glass, which is then inverted to allow the excess of alcohol to escape: the edges of the glass are wiped free of alcohol and the remaining film within the glass ignited. The glass is then applied to the affected area. The skin becomes congested and rises in the glass. By far the best, most rapid, and accurate cupping apparatus is the Allen surgical pump, which is shown in Fig. 82. The degree of suction can be regulated to a nicety and any number of cups applied in quick succession.

FIG. 82.

Allen pump, employed in lavage, illustrating its range of utility.

Wet cupping implies the abstraction of blood from the body. Formerly it was done with a complicated instrument containing ten or twelve sharp knives working in a half-circle through slits in a metal plate fixed to a frame. The instrument is rarely or never used to-day. The complicated mechanism made it difficult to render it aseptic and to keep in order. A better way is to scarify the part with a tenotome or bistoury and apply the cupping-glass as before described. The amount of blood withdrawn will depend upon the degree of suction and the depth of the cuts. The cupping ended, an antiseptic dressing should be applied.

(5) **Leeches.**—These are not often used at the present time. There are two varieties, the *American*, which can abstract about a teaspoonful of blood, and the *Swedish*, which draws about three or four teaspoonfuls. The latter is most commonly used.

Leeches may be applied as follows: The skin of the region selected is washed and, if necessary, shaved; it is then smeared with milk or blood. The leeches are taken from their receptacle and allowed to swim in a basin of fresh water for two or three minutes, after which they are urged to crawl over a clean towel for a similar period. Each leech is then taken up in a test-tube or small glass, and this is inverted over the spot chosen, when the leech usually fastens upon the skin. Sometimes considerable time elapses before it will attach itself. When it has drawn sufficient blood a little salt or snuff will make it relax or drop off. The wound may then be dressed with some antiseptic gauze. When the bleeding continues too long, pressure, styptic cotton, or solid nitrate of silver may be applied to the point. Haycraft ascribes the continued bleeding sometimes met with to the anticoagulating substance secreted from the pharnyx of the leech. If the bleeding

be insufficient, it may be encouraged with heat in the form of poultices or fomentations.

Care must be exercised in the application of leeches. They should never be applied over loose cellular tissue, such as the scrotum, penis, or eyelid, nor over superficial veins, arteries, or nerves. When applied to the neighborhood or interior of cavities they should be prevented from going too far, either by stuffing the continuation of the cavity with cotton or gauze or by securing the leech.

The *mechanical leech* is a device consisting of a scarificator-cup and exhausting syringe. After scarifying the part the cup is applied, a vacuum produced, and the blood slowly withdrawn. It is in no way comparable to the Allen pump, which possesses other advantages as well.

Paracentesis.

Paracentesis may be performed in one of three ways—viz. *aspiration*, *tapping*, or *incision*.

Aspiration is the withdrawal of fluid from a closed cavity without the admission of air by means of an instrument with which a vacuum is produced and an outward flow of the fluid induced. There are many kinds of aspirator, from the piston trocar to the more elaborate bottle-aspirator of Potain, which is the one most commonly used. It consists of a suction-pump connected with a bottle by rubber tubing and provided with stopcocks; the bottle is, in turn, connected in a similar way with the needle.

Fig. 83.

Aspiration of shoulder-joint.

The bottle is first exhausted of air, when the needle is inserted into the cavity containing the fluid, the stopcock is turned, and the fluid flows into the bottle. Should this become full, the stopcock is turned off, the bottle emptied, and the process repeated until the desired amount of fluid has been withdrawn. The area about the point to be aspirated should be thoroughly aseptic, as should the instrument in all its parts, especially the needle or trocar.

The place of puncture may be made anæsthetic with ice, rhigolene spray, or, what is usually more convenient, by touching it with a drop of carbolic acid, which is both antiseptic and anæsthetic. Aspiration is more commonly employed to remove effusions within the pleural, pericardial, ventricular, and subarachnoidian cavities, encysted collections within the abdomen, and fluid in the joints, especially the knee.

Tapping is effected by means of the *trocar* and *cannula*. (See Fig. 84.) The same preparation of the instrument and parts should be made as in aspiration. The instrument should be plunged quickly and firmly into the cavity and the trocar withdrawn. If the trocar be a large one, it is better to first incise the skin with a scalpel to prevent the opening in the skin from remaining patulous. Where a large collection is to be removed it is well to attach a piece of rubber tubing to the cannula to carry the fluid into some receptacle, and thus avoid wetting the patient's clothing and immediate surroundings. Tapping is usually applied in

FIG. 84.

Trocar and cannula.

dropsy, and when neither an aspirator nor trocar can be obtained the *valvular incision* may be employed. The skin having been drawn well aside from the line selected, an incision is made down through the skin and underlying tissues until the cavity is reached, and when drained sufficiently the skin is allowed to slip back to its original position. This puts the incision through the skin well to the side of that through the tissues beneath, and gives to the whole the action of a valve. The method has been successfully used in pleural and joint effusions, in spina bifida, and in cold abscesses.

The technique of these procedures in special cases will be given in their proper place in this work.

COUNTER-IRRITATION.

Like abstraction of blood, *counter-irritation*, except in the milder and less effective forms, has dropped out of fashion. So pronounced is the writer's conviction upon the value of this procedure as accomplished by the actual cautery that he regards the Paquelin thermo-cautery as an almost *indispensable part of a surgeon's armamentarium*. Counter-irritation is of *especial value* in the treatment of chronic inflammation (so called) the result of chronic congestion and tissue new formation, in which condition it both *relieves pain* and *promotes the absorption* of existing exudates.

Of the modus operandi, it is uncertain whether the good effects are due to the withdrawal of blood from the congested part or to the irritation of the terminal nerves, thus producing changes in the innervation of the diseased part. The degree of counter-irritation employed will depend upon circumstances, and may vary from mild reddening of the skin to actual destruction of the same, together with the adjacent underlying tissues.

The various means of producing counter-irritation include *rubefacients*, *vesicants*, the *seton*, and the *actual cautery*. To these may be added *issues* and *acupuncture*, which, however, are rarely ever used at the present time.

(1) *Rubefacients.*—In this list are found hot water, turpentine, mus-

tard, ammonia, capsicum, chloroform, and others, most of which, if applied sufficiently long, produce a vesicant action. Speaking broadly, the effect of rubefacients is not of signal value in most surgical conditions requiring counter-irritation, and, inasmuch as their method of application is so generally understood, we may pass them by without further consideration.

(2) *Vesicants* cause an effusion of serum and lymph under the skin. Chief among these are mustard, cantharides, chloroform, and ammonia.

Mustard is usually employed as a plaster made by mixing equal parts of the flour with wheat or flaxseed meal, to which enough lukewarm water has been added to make a paste. (It should be remembered that boiling water, by altering the active principle, renders mustard valueless as a vesicant.) It may also be conveniently used in the form of the mustard leaf, which is first dipped in warm water and applied. In either form the plaster should be left *in situ* for half an hour or more, and applied directly to the skin without intervening gauze or ointment, as is done where the rubefacient effect alone is desired. Although always at hand, and therefore convenient, mustard is not to be commended as a vesicant, because it is more painful than others to be mentioned and the resulting ulcers are often very slow in healing.

Cantharis is used in two forms—the *cerate* and *cantharidal collodion.* The cerate may be spread upon adhesive plaster, leaving a margin sufficient for adhesion to the skin in order that the cerate may be held in place. It should be removed in from six to ten hours and followed by a poultice. Cantharidal collodion is an admirable form in which to use this drug, its advantages being that it is not easily displaced and can be applied to irregular surfaces. It is painted on the selected surface with a brush, several layers being applied. *Chloroform* and *ammonia* are both used in a similar way. A few drops are applied upon the skin and covered with a watch-cover, or absorbent cotton saturated with them may be applied and covered with oiled silk, greased brown paper, or some impervious material. Within half an hour vesication has been usually produced. The use of these agents is open to the same objections as in the case of mustard—viz. pain and slow-healing ulcers. Silver nitrate, in strong solution, or the solid stick applied to the skin, produces vesication.

General Rules for Use of Blisters.—1. The region to be blistered should be thoroughly cleansed with soap and brush to remove natural oil, and, if hairy, should be shaved.

2. Poultices aid in the formation of a blister and diminish pain.

3. In using vesicants care should be taken not to bring the hands in contact with the eye.

4. Where the first effect alone is desired the bleb may be drained by inserting a common sewing-needle through the unaffected skin about an eighth of an inch from the margin of the bleb. This is usually painless.

5. Where the counter-irritant effect is to be prolonged, the raised cuticle having first been removed, savin ointment in full strength or diluted with vaseline, according to circumstances, or, better still, mercurial ointment, may be applied. This latter produces a powerful counter-irritant effect. Repetition of the blister may be resorted to also; indeed, a single blister is rarely sufficiently effective, three or four being usually necessary, in which case the succeeding blister is applied just after the sore from the one preceding has healed.

6. A large area should not be blistered at one time. A number of smaller blisters is safer and equally effective.

7. The use of blisters in children and persons with delicate skin requires especial caution.

8. The effect of cantharis in producing renal congestion and inflammation is to be remembered.

9. Blisters should be placed a little remotely from the inflamed area (unless this is deep-seated) and over the cutaneous nerves which are in relation with those going to the diseased area.

10. The use of blisters directly over diseased areas lying near the skin may aggravate the disease. If the inflammation, however, has passed away, blisters may promote absorption.

(3) *The Seton.*—This consists of a *subcutaneous sinus* with two openings, through which some *foreign body*, usually silk, is passed.

This is easily made by thrusting a needle having a generous eye and armed with large silk through the desired place, the ends of the silk being tied together. After two or three days the wound is dressed and the silk drawn back and forth through the wound a few times, this being subsequently repeated daily. The irritant effect may be increased by smearing *savin* or *mercurial ointment* upon the silk. The writer has employed the seton in post-cervical pain with marked benefit.

(4) *The Actual Cautery.*—In point of view of wide range of applicability, efficiency, and speedy action the actual cautery ranks first among counter-irritants. The old cautery-irons, the red- or white-hot poker, and other crude forms have been superseded by the *Paquelin thermo-cautery*, shown in Fig. 85.

Fig. 85.

Use of the actual cautery as a counter-irritant.

Its principle depends upon the power of benzine to render heated spongy platinum incandescent. Having heated the tip in an alcohol flame, the rubber bulb connected with the benzine receiver is compressed and the benzine vapor is forced into the spongy platinum, which becomes heated to any degree up to white heat, according to the pressure upon the bulb.

When ready for use the following precautions should be observed: The part to be cauterized should be thoroughly cleansed and shaved. The cautery, having been brought to a white heat, should be touched upon the part in spots half an inch distant from each other, or in the form of streaks parallel or crossing each other. The amount of pressure and the duration of contact upon the skin will determine the depth of the burn, which it is better to limit to partial rather than to entire destruction of the cuticle.

The *counter-irritant effect* in the former condition is greater because of the exposure of the terminal ends of the sensory nerves. After cau-

terization has been produced the part may be dressed with ice-water, poultices, with or without some anodyne or an ointment containing 10 per cent. of iodoform. Where it is desired to keep up the effect the ulcer may be dressed with *savin* or *mercurial ointment*, as previously mentioned when speaking of blisters. It is proper to mention here that the thermo-cautery may be used to produce a rubefacient effect. This is done by heating the largest tip to a white heat and holding it within a quarter or half an inch of the surface until the pain causes the patient to exclaim or the skin is seen to redden, when it should slowly be shifted an inch or so. The writer has found this of great *sedative value* in tympany following laparotomy after synovitis and other analogous conditions.

Ignipuncture—*i. e.* puncture with a fine cautery-point, made by plunging it into the skin and underlying tissues in a number of places—produces admirable counter-irritation in deep-seated congestions or inflammations.

CHAPTER XVIII.

MINOR SURGERY AND BANDAGING.

By John Parmenter, M. D.

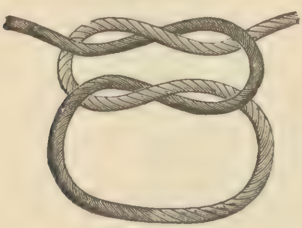
Knots.

The knots in common use by the surgeon include the reef or square knot, the surgeon's knot, the granny, the Staffordshire knot, and the clove hitch.

(*a*) The *reef knot* is formed by passing one end of the ligature over and around the other, drawing the single knot thus formed sufficiently tight, when the process is repeated, using the same end that was first employed.

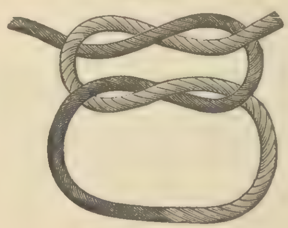
(*b*) The *surgeon's knot* differs from the reef knot only in the first stage of its formation, where the one end is carried over and around the other twice. This makes the knot more secure by preventing the slipping of the single knot while the second is being made—an accident which easily occurs where great tension is

Fig. 86.



Reef knot.

Fig. 87.



Granny knot.

Fig. 88.

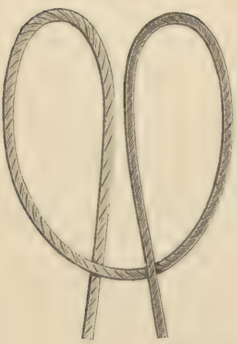
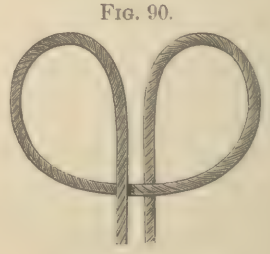


Fig. 89.

Clove hitch.

Fig. 90.



Staffordshire knot.

necessary or slippery ligature materials are used. The surgeon's knot requires more force to produce the same amount of tension.

(*c*) The *granny* differs from the reef knot in that in the second stage of its formation the end first employed is passed under and around its fellow. It is a good knot, easily made and thoroughly secure, some authorities notwithstanding.

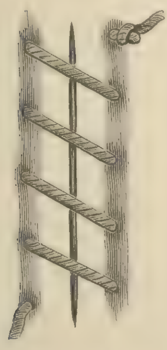
(*d*) The *Staffordshire knot* is especially useful for securing pedicles. It is made by transfixing the pedicle with a double-threaded transfixing needle, slipping the loop over the stump, and pushing it down to the point of entrance of the ligatures (the needle having been withdrawn), when one ligature is placed over and the other remains under the loop: each is pulled tightly and secured by a square knot. The Staffordshire knot thus secures each half of the pedicle, and is a safe and reliable knot when properly made. When carelessly made it is highly dangerous.

(*e*) The *clove hitch* may be properly considered in this place, although not employed in the class of cases in which the knots just described are used. It is easy to make and does not slip. In fact, the more it is pulled upon the more secure becomes its grasp. Its formation is best conveyed by observing Figs. 88, 89.

Sutures.

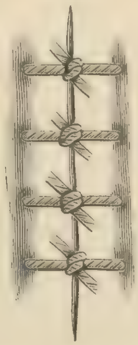
Sutures are employed in various forms according to the necessity of the individual case or the preference of the operator. Those in most frequent use are:

Fig. 91.



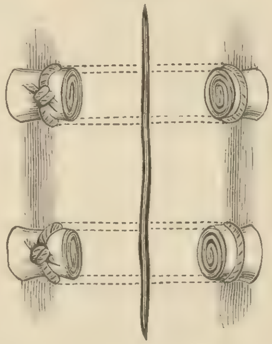
Continuous suture.

Fig. 92.



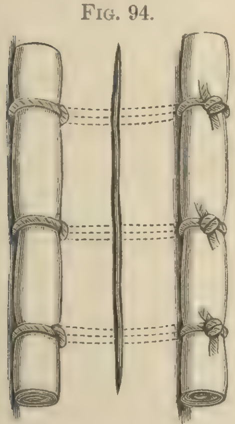
Interrupted suture.

Fig. 93.



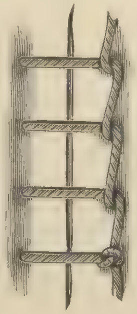
Modified plate suture, using gauze instead.

Fig. 94.



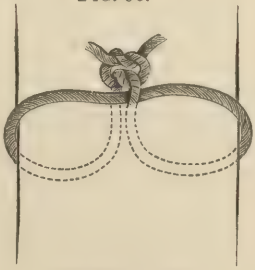
Modified quill suture, using gauze.

Fig. 95.



Billroth's chain-stitch.

Fig. 96.



Transfixion suture.

(*a*) The *continuous suture* (Fig. 91) is made by passing the needle in at one side of the wound and out through the other at an opposite point, when the suture is

tied: the needle is again inserted into the side first penetrated and brought out upon the opposite side. This process is repeated until the wound is closed, when the double thread is tied with single thread into a square knot. This suture can be quickly placed, and if done with due care leaves a good scar. It is easy to strangulate the lips of the wound if more than moderate force be employed. Furthermore, unless the wound be quite dry the continuous suture requires that drainage be coincidently employed, as wounds thus closed are too tight to permit much escape of fluid from underneath. In long wounds it is well to tie the suture at varying intervals to avoid giving way of the entire suture should a part fail.

(*b*) The *interrupted suture* is the form most commonly employed. It is made by passing the needle through the tissues from one side to the other at an opposite point; the suture is then tied with an appropriate knot and cut off. The process is repeated as often as necessary, the sutures being from one-quarter to one-half an inch apart according to the tension.

(*c*) The *plate*, *transfixion*, and *quill sutures* are shown in Figs. 93, 94, 96, and require no special description. They are all useful where tension is to be overcome or close approximation is required. Gauze makes an admirable substitute for the plate or quill.

(*d*) The *Lembert suture* is used in intestinal surgery. It includes all the coats of the intestine except the mucous. When the sutures are tied the serous surfaces are approximated. The sutures should be placed about one-eighth of an inch apart.

(*e*) The *Czerny suture* brings the edges of the wound directly into apposition, but is employed only in intestinal suture, which see in Vol. II.

Secondary sutures are used in cases where from hemorrhage or expected suppuration the surgeon has been compelled to pack the cavity with gauze. The sutures (of non-absorbable material) are placed, but not drawn so as to coapt the edges of the wound. After a few days the packing is removed and the sutures tied, so as to bring the lips of the wound into apposition.

Removal of Sutures.—Sutures are usually left in place from four to nine days: the time varies with the vascularity of the region and the tension. The knot should be seized with dressing-forceps and pulled upward and to one side, when the suture will show the part previously just underneath the skin and easily recognizable by its bleached appearance and moist condition. This is divided with appropriate scissors in the moist part, and the suture removed with the forceps previously applied to the knot. This detail of cutting through the moist part of the suture should be observed, as by dragging a dried part of the suture through the wound the latter may be easily infected.

Transfusion and Infusion.

The object of these procedures is to give bulk to the blood in the vessels from which it has been in part withdrawn through hemorrhage, to add nutriment, and to furnish red blood-corpuscles to the blood. That the two latter effects are ever produced is very doubtful. The giving of additional bulk is of unquestioned efficacy.

The **transfusion of blood**, either directly or indirectly, from an animal or a human being into an exsanguinated person is to be mentioned only to be *condemned*. It has been proven beyond doubt that the injection of defibrinated blood into the circulation is a dangerous procedure. After a few days the red corpuscles injected die, hæmoglobin is set free, and quickly causes destruction of the white blood-corpuscles, with formation and accumulation of fibrin-ferment, and not infrequently death of the individual.

Direct transfusion is much less dangerous, but impracticable, as it is commonly difficult to find one ready to donate the blood. Furthermore, the blood may coagulate in the conducting tube, and under any circumstances it is doubtful whether the red corpuscles thus injected retain their vitality.

It seems, therefore, needless to describe the technique of transfusion, which is attended with so many dangers, and for which the infusion of a normal 0.6 of 1 per cent. saline solution may be more safely and advantageously substituted. A good formula is aq. destil. 1000, sodii chloridi 6.0, sodii carb. 1.0. This should be sterilized, warmed to 39° C., and rendered alkaline by the addition of one drop of sodium hydrate (sat. sol.) to every half-litre of the solution. Ludwig suggests the addition of from 3 to 5 per cent. of sugar to the alkaline solution, claiming that the addition of the sugar adds nutritive value, increases endosmotic action, whereby the blood absorbs the parenchymatous fluids more readily, and furthermore preserves the red blood-corpuscles from destruction better than the plain solution. The apparatus required consists of a glass funnel with rubber tube attached, which, in turn, is connected with a glass cannula. In order that the pressure exerted by the infused solution should not exceed that in the large veins the flask should be held a few inches above the level of the opening in the vein. Eighty or ninety cubic centimetres should be injected each minute until from 5 to 1500 c.c. have been used, according to the individual case. The quality of the pulse will indicate when sufficient has been injected. Kneading of the abdomen favors the diffusion of the solution.

An admirable and efficient substitute for the above-described method is the *subcutaneous infusion* of the same solution, which is prepared, sterilized, and warmed as previously mentioned. This is then injected under the skin with an appropriate needle in amounts varying in all from 500 to 1000 c.c.

The anterior abdominal wall and the thighs are good regions in which to inject the solution. Massage helps the absorption of the fluid. In the absence of the normal saline solution pure warm water may be used, but is not so readily absorbed. Milk also has been recommended, but the best authorities agree that it is a dangerous agent and should not be used for this purpose.

Catheterization.

Catheters are used chiefly to withdraw urine from and to wash out the bladder. Three kinds are in common use—viz. the *metal*, *gum*, and *flexible*—each of which has its distinctive advantages. In addition there are special forms, such as the *prostatic*, the *elbowed* (catheter Coudé), and the *olivary*.

The technique of catheterization varies with the form employed and the condition of the urethra. In the following brief description a normal urethra and a stiff catheter are presupposed: Having placed the patient preferably in the recumbent position, and having selected a good-sized catheter (No. 24 French) which has been previously made aseptic, well warmed, and thoroughly oiled, the operator holds the same between the thumb and forefinger of his right hand. Resting the little finger of the same hand upon the patient's abdomen at or just beneath the umbilicus, the catheter is inserted into the meatus, when the penis is slipped over the catheter as far as it can be made to go. (This procedure has the advantage of rendering the urethra smooth by obliterating the folds

of the mucous membrane.) The catheter is then carried from its horizontal to a vertical position, when by pressing slightly downward and at the same time depressing the shaft between the thighs of the patient the instrument will usually glide into the bladder.

Cleansing of Catheters.—Catheters should be kept in a strictly aseptic condition, otherwise inflammatory troubles, such as urethritis and cystitis, are prone to occur. After using, the catheter should be thoroughly rinsed in clean water, care being taken to remove all clots or débris from the bore of the instrument. (That portion of the catheter between the eye and the tip is most liable to be insufficiently cleansed.) If running water be not at hand, water may be forced through the catheter with a syringe, and considerable pressure should be used to ensure dislodging of the material contained within. This done, it should be followed with some antiseptic solution, such as carbolic-acid solution, 1 : 20, Condy's fluid, etc.

Metal and glass catheters have the advantage that they may be sterilized by boiling. Other catheters after lying for twenty minutes in the antiseptic solution may be carefully dried and laid away for future use, wrapped in some impervious material like rubber tissue, oil silk, and the like. Glass catheters may be kept in the antiseptic solution permanently.

Normal Obstacles to Catheterization.—The novice may encounter several points along the normal urethra which tend to prevent the further passage of the instrument :

1st. The catheter may *catch* in the fossa navicularis, an accident which may be easily avoided by keeping the tip close to the floor of the urethra during the first part of its passage.

2d. It may be *stopped* at the triangular ligament. When this occurs the catheter should be withdrawn a little and the tip made to hug the roof of the urethra.

3d. *False passages*, previously made by using misdirected and excessive force. These are often difficult to avoid, but can usually be circumvented by keeping the tip of the catheter close to the side of the urethra opposite the opening of the false passage.

4th. The *neck of the bladder may form an obstacle*, under which circumstances withdrawing the stylet a little, and thus tipping up the end of the catheter, will usually cause it to ride over the urethral floor into the bladder.

Untoward Effects sometimes following Catheterization.—These are both local and constitutional. Chief among the local effects we have—

1st. *Pain.*—This is usually severe in nervous persons upon whom the catheter is passed for the first time. It may be mitigated by exercising gentleness and thoroughly oiling the instrument. A 4 per cent. solution of cocaine may be previously injected if deemed necessary or advisable.

2d. *Hemorrhage.*—When this occurs it is rarely serious, and ceases soon after withdrawal of the instrument. If ordinary care has been used and hemorrhage follows, it usually denotes a pathological condition of the urethral mucous membrane.

3d. *False Passages.*—As before said, these are usually due to misdirected and excessive force, but may occur from very slight pressure

when the mucous membrane has been congested for a long time from previous disease. Their occurrence may be recognized by the sudden giving way of previous resistance, sudden pain, followed by a sensation of grating appreciable alike to patient and operator. Further confirmation may be gained by noting any deviation of the handle of the catheter from the median line, by feeling the tip out of the middle line upon rectal palpation, and by the fact that no urine escapes. False passages may be avoided only by exercising the greatest gentleness and intelligence in manipulation.

4th. *Extravasation of Urine.*—This occurs in connection with false passages alluded to, and the prevention of the latter implies avoidance of the former.

5th. *Inflammatory conditions*, such as abscess, urethritis, prostatitis, and cystitis, not infrequently result from the use of unclean catheters, mere mention of the cause, uncleanliness, indicating how best to avoid the condition.

Constitutional Conditions.—The more common constitutional conditions may be traced to the effects of catheterization upon the nervous centres or to sepsis. Of the former we have, chiefly—

1st. *Syncope, Retention, and Suppression of Urine.*—The use of cocaine and the recumbent position, combined with the greatest gentleness during the passage of the catheter, will do most to prevent or mitigate these unpleasant and sometimes dangerous effects.

2d. *Urethral Fever.*—This is believed by some to be of nervous origin, by others to be due to the absorption of toxic alkaloids. The use of measures similar to those employed in the case of syncope are usually of pronounced value.

3d. *Pyæmia.*—This may occur even with the formation of metastatic abscesses, and is usually due to infection from without. The writer has seen one case of purulent synovitis of the knee-joint result from the use of an unclean catheter; at least this seemed to be the only solution of the origin of the trouble, inasmuch as commoner causes of this affection could be pretty safely excluded.

Artificial Respiration.

There are various methods of producing artificial respiration, some of which accomplish the result through pressure upon the thorax, others by means of direct inflation of the lungs. Of the former methods, those in most common use are *Sylvester's*, *Marshall Hall's*, and *Howard's*.

Of these, *Sylvester's* is the simplest and easiest of execution. This method makes use of the arms as levers to expand the chest through the medium of the muscles which pass from the arms to the chest-wall, the origin and insertion of these muscles interchanging at each step. The patient is laid upon his back with the shoulders somewhat elevated by a pillow or cushion placed under them, the neck extended, and the head thrown back. The tongue may be drawn forward by an assistant if necessary. Foreign bodies, including water, must be removed from the pharynx. The surgeon should then seize the forearms just below the elbows and carry them over the patient's head as far as they can go. This action expands the thorax. A little extra jerk when the arms are at their highest point increases the efficiency of the movement. The arms having been thus held about two seconds, they should be brought down to the sides of the thorax and pressed firmly against the same for two seconds, when they are again elevated, and the

entire procedure repeated until no longer necessary. Pressure against the liver upward assists in emptying the lungs of their contents. The number of complete movements in a minute should equal that of normal respiration (sixteen to eighteen). If the patient be small, it is important that the feet be firmly held to prevent the body being pulled forward when the arms are carried upward. Should this occur, the efficiency of the procedure in expanding the thorax will be much diminished.

Marshall Hall's method is practised as follows: The patient is rolled from the position on his back to that on his side; the uppermost arm is pulled forward and pressure made directly upon the side of the thorax to expel the air from the lungs. The body is then rolled over on to the back, which movement causes respiration. The process is repeated as often as sixteen or eighteen times per minute. The method is not as efficient as that of Sylvester.

Howard's method is best described in the words of its author: 1. Instantly turn patient downward, with a large firm roll of clothing under stomach and chest. Place one of his arms under his forehead, so as to keep his mouth off the ground. Press with all your weight two or three times, for four or five seconds each time, upon patient's back, so that the water is pressed out of lungs and stomach and drains freely out of mouth. Then, 2, quickly turn patient, face upward, with roll of clothing under back just below shoulder-blades, and make the head hang back as low as possible. Place patient's hands above his head. Kneel with patient's hips between your knees and fix your elbows firmly against your hips. Now, grasping the lower part of patient's naked chest, squeeze his two sides together, pressing gradually forward with all your weight for about three seconds, until your mouth is nearly over mouth of patient; then with a push suddenly jerk yourself back. Rest about three seconds; then begin again, repeating these bellows-blowing movements with perfect regularity, so that foul air may be pressed out and pure air be drawn into lungs, about eight or ten times a minute for at least one hour or until patient breathes naturally.

The above directions must be followed on the spot the instant patient is taken from the water. A moment's delay and success may be hopeless. Prevent crowding around patient; plenty of fresh air is important. Be careful not to interrupt the first short natural breaths. If they be long apart, carefully continue between them the bellows-blowing movements as before. After the breathing is regular let patient be rubbed dry, wrapped in warm blankets, take hot spirits and water in small, occasional doses, and then be left to rest and sleep.

The procedures based on direct inflation of the lungs include *mouth-to-mouth inflation* and *forced respiration.*

Mouth-to-mouth inflation is practised in the following way: The tongue having been drawn forward, the operator applies his mouth directly to the mouth of

FIG. 97.

Fell's apparatus for forced or artificial respiration.

the patient, at the same time closing the nostrils. The operator then blows into the mouth of the patient, following this action with forcible pressure upon the

walls of the thorax. This process should be repeated fourteen times in a minute. A good modification is to blow through a catheter which has been previously passed through the larynx, or to pass an intubation-tube to which has been attached a rubber tube through which air can be easily forced.

Forced respiration is effected by means of a bellows, the best form being that elaborated by Dr. George E. Fell of Buffalo. With it air can be forced into the lungs, either directly through the mouth and larynx or through a tracheotomy-tube. The writer has had occasion to test the efficacy of this apparatus a number of times, and cannot exaggerate its usefulness.

Whatever form of artificial respiration be made use of, such adjuvants as warmth, stimulation, and rubbing of the body in the direction of the venous circulation are not to be forgotten.

Corns.

Corns belong to the papillomata, and may be defined as an undue development of the cuticle attended with increased vascularity of the underlying cutis and more or less enlargement of its papillæ. They are caused by intermittent or occasional pressure. There are two varieties—the *hard* and the *soft*—the former situated upon exposed parts like the little toe or the back of the toes, the latter being found between the toes and deriving their character from the moisture usually existing in this place. For the same reason a soft corn grows more rapidly than a hard one.

Corns are usually flattened and circular in shape externally, and extend beneath the skin in a conicular wedge-shaped manner. It is to this latter circumstance, whereby the apex of the cone or wedge presses upon the sensitive papillæ underneath, that corns owe their painful character. Old corns frequently have a bursa develop underneath them. This may become inflamed and even suppurate, a process usually very painful and occasionally terminating in ulceration, which may perforate deeply into the tissues, even to the bone.

Treatment.—The treatment should combine prevention of recurrence with destruction of the corn. When new and small, corns will commonly disappear on removing the pressure of tight or ill-fitting shoes and placing around the corn a felt ring (U-shape), whose edges shall take the pressure of the shoe from the corn. When it has existed for a long time a hard corn should be thoroughly softened with warm water, after which a solution containing salicylic acid 1 drachm, ext. henbane 4 grains, flexible collodion 1 ounce, may be painted upon the part once or twice a day. Iodine, potassium chromate, silver nitrate, and other similar agents have been recommended. Inflamed corns should be treated by elevation and rest of the part, together with antiseptic fomentations. If pus forms, it should be evacuated, great and almost immediate relief usually following. (*Vide* also Chapter XXVII.)

Bunions.

A bunion is an *enlarged normal bursa* or one produced *adventitiously* by the pressure of an ill-fitting shoe. Bunions are usually found on the inner side of the great toe at the metatarso-phalangeal joint. When the shoe has its inner border slanting outward, as in very pointed shoes, or

it is too short and narrow, the best conditions are present for producing a bunion. Another cause is prolonged continuous standing upon a weak tarsus, which produces flat-foot and the oblique outward direction of the great toe which accompanies the condition. It may become much enlarged and inflamed, and not infrequently terminate in suppuration. Very commonly, too, the joint becomes prominent on its inner side from enlargement of the head of the metatarsal bone. In extreme cases the great toe may lie at almost a right angle to the long axis of the foot and over or under the adjacent toe. In such cases the deformity is pronounced and the interference with walking quite marked.

Treatment.—This is preventive or curative. Remembering the etiology of bunions, it is apparent that proper shoes are necessary. The inner side of the shoe should be almost straight, there should be sufficient width to permit the foot to spread normally, and the shoe should be sufficiently long. When inflamed the foot should be elevated and put at rest. Incision is indicated when pus is present. In the old and inveterate forms, without much or any inflammation, a blister may be applied, and its counter-irritant effect maintained by rubbing in an ointment of biniodide of mercury, 10 grains to the ounce of lard. Where the head of the metatarsal bone is unduly enlarged and the deformity great, excision of a wedge-shaped piece of bone, followed by fixation of the toe in a normal position, is indicated. Except in very old and feeble subjects amputation is rarely called for.

Ingrown Toe-nail.

Two causes operate to produce ingrown toe-nails: one is the pressure of a shoe or tight stocking which is too narrow; the other is the overgrowing of the cuticle adjacent to the edge of the nail. This latter is a very common cause, which is frequently aided by the bad practice of rounding off corners when cutting the nail. In the milder grades of the trouble there is little to be seen on inspection except the overhanging cuticle. When, however, ulceration has occurred, the side of the nail may be covered with foul granulations which exude pus. The pain and inability to walk may be very great when the inflammation is pronounced. In some severe cases widespread cellulitis may be present.

The *therapeutic indications* are to remove pressure either of the shoe or cuticle and to substitute healthy for unhealthy granulations. Patients with ingrown toe-nails should wear well-fitting shoes and stockings. When the cuticle overhangs it may be pushed back into normal place by inserting a small roll of cotton under the edge of the nail and along the border of the same. Adhesive plaster applied so as to draw the cuticle from the edge of the nail has proved of signal value in the writer's hands. In the more severe cases the granulations should be touched with silver nitrate or copper sulphate, or, better still, they should be curetted away and the remaining surface thoroughly disinfected and cauterized. Others, again, may only yield when to the above treatment is added continuous pressure and some astringent powder. This may be done by dipping a small hard roll of absorbent cotton into powdered lead nitrate and binding it over the granulating surface with adhesive plaster. Sometimes removal of the contiguous portion of the

nail is indicated, but this procedure is rarely necessary if both patient and surgeon will exercise a little patience and employ treatment along the lines above indicated.

Skin-grafting.

The two recognized methods of skin-grafting include that of (*a*) Hamilton or Reverdin; (*b*) of Thiersch.

(*a*) **The Hamilton or Reverdin Method.**—This consists in spreading upon the granulating surface minute portions of the epidermis which have been shaved off from some convenient region (callus in the palm of the hand is useful). These are placed about one-quarter of an inch from each other. They adhere to the underlying granulations, upon which they spread until they coalesce with neighboring spots. Ulcers treated in this way heal rapidly, but when extensive are apt to be followed by a weak scar and considerable contraction.

(*b*) **The Thiersch Method.**—In this method about half the thickness of the skin is used. It is removed by putting the skin on the stretch either with broad sharp retractors or by grasping the part so as to accomplish the same effect, when, with a keen razor previously wet with a sterile normal (.6–1.0 per cent.) solution of common salt, strips anywhere from one to twelve inches long are removed. These are transferred to the wound upon the razor-blade or a spatula, and spread evenly and closely upon the surface with probes. The preparation of the granulating surface for the reception of the grafts is of vital importance to success. It should have been made aseptic and healthy. When granulations are deep red or "raw beef" in color, with little or no pus, and cicatrization has already begun, we have the best surface for grafting. It is not necessary, however, to wait until this condition is present. Provided the surface be aseptic, the superficial granulations may be curretted off, a very light touch being sufficient to do this. It has been recommended to remove any line of cicatrization which may be already formed, as experience has shown that subsequently ulceration frequently occurs in just this place. All hemorrhage is to be thoroughly checked before the grafts are put in position. The after-dressing consists in first placing a layer of sterilized green protective or rubber tissue sufficiently large to cover the entire surface and overlap the edges a little. This is to be laid on evenly, and over this are applied gauze compresses saturated in the normal saline solution and absorbent cotton, all firmly held in place with a bandage. Gold- or tin-foil may be used in place of the protective or rubber tissue, and sterilized oil may be substitued for the saline solution.

The oil dressing is certainly more convenient than the solution, with which the dressings must be kept constantly saturated to ensure success. Any dressing which sticks is apt to dislodge the grafts, their adhesion to the underlying surface in the first few days being very slight. *No antiseptic solutions should come in contact with the grafts.* The dressing should not be changed under four or five days, and should then be removed with the greatest care lest the grafts be disturbed. A similar dressing should replace the first, and not be discontinued under two weeks, after which some ointment may be used. The advantages of the Thiersch method are the rapidity of healing of extensive defects and the relative non-contractility of the new skin thus formed.

Extraction of Teeth.

There is, perhaps, no minor surgical procedure which requires for its proper completion a more thorough application of anatomical knowledge and more manual dexterity than the extraction of teeth. When one considers the frequency with which the average practitioner is called upon to perform the operation, it is apparent that he should possess sufficient knowledge to appreciate the dangers arising from the application of immoderate and misdirected force.

Conditions demanding Extraction.—There are various conditions which demand the extraction of teeth. Chief among these are the various inflammatory conditions resulting in abscess of the alveolus of the root or the destruction of the crown from caries; old stumps and teeth with sharp or ragged edges which may irritate the inside of the cheek or the tongue, producing ulcers and even epithelioma; irregular, impacted, and overcrowded teeth; various operations upon the jaws, such as resection, tapping the antrum of Highmore, etc.; and, finally, incessant toothache not remediable by any other means.

Instruments Required.—The instruments required are forceps and the elevator. There should be at least five pairs of forceps, and, better, seven. (The more experienced, however, the operator the fewer the forceps needed.) The forceps have various shapes to meet the requirements. The elevator is of use where the forceps cannot be applied, as, for instance, in troublesome stumps lying beneath the alveolar border.

Method of Extraction.—To extract teeth properly the operator should bear in mind certain anatomical points. The teeth are arranged in the form of an arch in which each tooth is a keystone, it being narrower at the inner alveolar border than at the outer. It can therefore be dislodged most easily by force acting in a direction outward—*i. e. toward the cheek.* Furthermore, the alveolar border is much thinner upon the outer than upon its inner side. (An exception must be made at the site of the third molar (wisdom) tooth.) The tooth should be seized with appropriate force upon the fang well beyond the crown. Pressure outward is then made, this frequently splitting the socket on the outer side and coincidently rupturing the periosteum on the inner side of the tooth. The pressure is then reversed and the tooth brought back into its original place, this motion causing the periosteum on the outer side to break. By quickly repeating these rocking movements the periosteum is entirely torn through and the socket sufficiently bent or split to leave the tooth free, when by adding a direct pull the tooth is extracted. Naturally, the technique varies somewhat with the tooth extracted and its situation, whether in the upper or lower jaw. In the upper jaw direct pressure upward permits the forceps to be easily applied to the fang. In the lower jaw the operator adjusts the forceps to the neck of the tooth and presses it down with the thumb of his left hand placed over it in the mouth, the fingers of this hand grasping the lower jaw firmly from below.

Accidents from Extraction.—(*a*) *Hemorrhage.*—This may be severe enough to threaten life in those having a hemorrhagic diathesis. Ordinarily it is not of moment.

The socket having been thoroughly cleared of clot, ice or ice-water may be put

into it, followed, if necessary, by a cotton plug soaked in some astringent, such as persulphate or perchloride of iron, tannin, alum, and the like. This plug should be pressed firmly into the socket and reach its uppermost part, otherwise the pressure of the blood will quickly dislodge it: should plugging prove inadequate, the fine point of a Paquelin cautery may be used with advantage. Where the tooth that has just been extracted is at hand, it may be placed in the socket and pressed firmly in. This often succeeds admirably.

(*b*) *Dislocation or Fracture of the Lower Jaw.*—These injuries should receive immediate treatment, the details of which will be found elsewhere.

(*c*) *Fracture of Opposing Teeth.*—This results from slipping of the forceps or their sudden and unanticipated release from breaking of the crown, etc., whereby the forceps hit the teeth above or below, as the case may be.

(*d*) *Fracture of the Tooth Extracted.*—When this occurs all pieces should be removed with appropriate forceps. Should the removal of the remainder of the fang require much bruising or breaking of the alveolus, it is better to postpone its removal until it has risen nearer the alveolar border.

(*e*) *Extraction of Healthy Teeth.*—This may happen through mistake, or a healthy tooth may be pulled coincidently with one diseased. The socket should be cleansed and the tooth washed in warm water and replaced. After pressing it firmly into place, it may be retained by closing the teeth and maintaining this apposition with an appropriate bandage.

(*f*) *Forcing a Tooth into the Antrum of Highmore.*—This accident is due to pressing too firmly in the effort to grasp the fang. The tooth should be removed and the parts thoroughly cleansed to avoid inflammation and suppuration within the antrum.

(*g*) *Tearing of the Alveolar Border.*—Careless application of the forceps is the usual cause. When slight the gum may be pressed into place. If more extensive, one or more stitches may be required.

(*h*) *Injury to the Inferior Dental Nerve.*—This may occur as the result of dislocation of the lower jaw or from fracture. Perfect reposition of the parts is the treatment indicated.

(*i*) *Dropping of a Tooth or of Pieces of Instruments into the Larynx.*—The result may be immediate suffocation, or, if the foreign body escape through the vocal cords, a septic pneumonia is apt to occur. To avoid this complication the operator should invariably make sure that the forceps have released the tooth previously drawn before again introducing them into the mouth. When the accident has occurred removal of the foreign body is imperative, and may be accomplished by appropriate measures.

Hypodermatic Medication.

Except where a drug is being constantly used it is better kept in the form of tablets than in solution, which latter easily deteriorates from keeping too long. Administration is made by means of a hypodermic syringe, of which there are various forms, all constructed, however, upon a common principle. It usually contains about thirty minims, and is graduated either upon the barrel or upon the shaft of the piston, that so a given number of drops may be injected.

Points of Election for Injection.—Injections are best given in places where there is sufficient subcutaneous tissue to permit the skin to be pinched up, and also where there are no perceptible veins. (Where it is desired to produce a local as well as a constitutional effect the injection may be made at the affected site.) Speaking generally, however, the outer side of the upper or lower extremities will be found the safest and best places for injection.

Method of Administration.—The surface selected having been thoroughly cleansed with alcohol or ether, the solution, just brought to the boiling-point in a spoon placed over a gas-jet or lamp, is drawn into the syringe. (The advantages of boiling are sterilization, readier absorption, and diminution of pain.) The needle having been adjusted, the syringe is then turned with the needle-point upward and all air expelled. The skin is pinched up between the finger and thumb of the left hand and the needle inserted with a quick thrust. Done properly, the entrance of the needle will be barely felt by the patient. When the needle has been inserted to almost its full length, the fluid should be slowly expressed, the needle being gradually withdrawn at the same time. This procedure helps to avoid the accident of injecting directly into a vein by constantly shifting the point of the needle. The injection completed, the needle is wholly withdrawn and the fluid further dissipated by gentle friction with the fore finger over the injected area. Where the skin is unduly sensitive a cloth wet in cold water should now be applied for fifteen or twenty minutes to allay irritation and congestion and possible inflammation.

Accidents.—(*a*) *Injection Directly into a Vein.*—This produces frequently very alarming symtoms. The patient becomes suddenly dizzy; the face, first pale, quickly becomes suffused; the temporal arteries may be seen throbbing vigorously; buzzing noises in the ears are heard. These phenomena are succeeded by a more or less violent congestive headache which may persist for several hours.

Severe as are the symptoms, the condition passes off, as a rule, without further detriment to the patient. In the writer's experience this accident is most apt to occur to those addicted to the use of the syringe. It is possible that in such persons the repeated injections have produced contraction in the connective tissue under the skin, as a result of which certain small veins have been made patulous by having their walls pulled upon from each side and their diameter increased.

(*b*) *Injury to a Nerve.*—This is sometimes severe enough to produce neuritis and pain which may persist for a long time. In this connection the writer has seen two cases in which almost immediately following an injection the skin of the whole arm became raised into irregular wheals of varying size and attended with severe itching and burning. Under cool applications the condition speedily disappeared.

(*c*) *Sepsis.*—Now and then cellulitis or a local abscess develops after injection. It can almost invariably be attributed to lack of cleanliness. Sometimes, however, it occurs in certain depraved constitutional states where direct infection can be fairly well excluded.

Care of the Syringe.—Much difficulty is often experienced in keeping the syringe in good condition. Either the needle becomes blunted or stopped up or the piston becomes dry and does not exert sufficient suction. By filling the syringe before attaching the needle the chief

cause of blunting—viz. striking the needle-point against the spoon—will be obviated.

After using, the needle should be blown through to remove all remaining moisture from the bore, or it may be well heated over the gas or lamp. Finally, by putting a drop of oil now and then between the washers of the piston the suction-power will be maintained. The screw caps accompanying syringes are of little or no use in preventing drying, as air readily enters along the shaft of the piston.

Bandaging.

The tendency in bandaging to-day is toward simplicity, and this is due in part to modern ideas of antiseptic and aseptic surgery and in part to the materials employed.

The need for elaborate descriptions of the various methods of band-

Fig. 98.

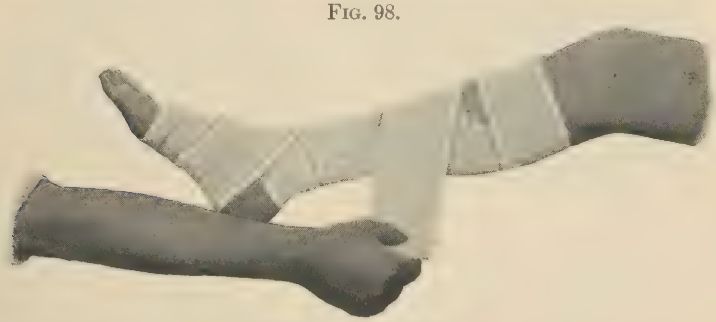


Figure-of-8 bandage of leg.

aging different parts of the body does not seem to exist, and therefore diagrams instead of verbal descriptions will be employed, the latter

Fig. 99.

Velpeau's bandage.

Fig. 100.

Ascending spica bandage of the groin.

being too complicated and indefinite to justify the space they occupy in the average text-book of surgery.

Among the materials used in bandaging may be included cotton, cheese-cloth, crinoline, gauze, flannel, rubber, and materials which have been impregnated with plaster of Paris, starch, silicate of sodium, etc. In selecting a bandage one must have in mind *the part to be bandaged*,

Fig. 101.

Fig. 102.

Head-and-neck bandage.

the *amount of restraint and support* required, the *length of time* the latter is to be maintained, the *effect* upon the *skin*, the *circulation* of the part, and such other considerations as may be indicated in individual cases. For instance, crinoline is easily impregnated with plaster of Paris,

Fig. 103.

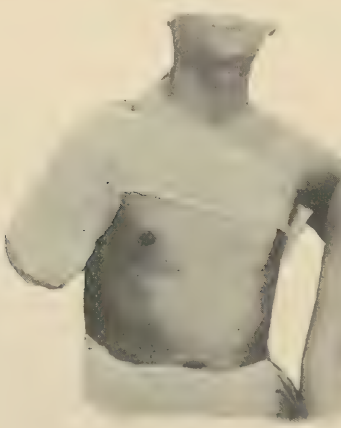


Fig. 104.

Spica bandage of shoulder.

starch, or other stiffening material, and when so used has peculiar advantages in giving firmness to the dressing. Where moderate firmness with some elasticity is desirable cotton is a good agent. We employ bandages to give rest and support to affected parts, to retain splints and dressings, to prevent or reduce swelling, and to check hemorrhage.

Bandages may be divided into three general classes—the *roller*, *triangular or scarf*, and *special* bandages. The **roller bandage** varies in width and length according to the requirements in individual cases. It is employed as the *single* or *double* roller, the former being the one in

Fig. 105.

Fig. 106.

Third roller of Desault's bandage.

common use. It is usually employed upon the head and extremities, although applicable to other situations.

Roller bandages are made in various sizes, the average being 2½ to 3 inches by 7 to 8 yards. They may be made into rolls for use, either by hand or with appropriate apparatus found in instrument-stores.

Fig. 107.

T-bandage.

Fig. 108.

Kelly's bandage with perineal straps.

The method of applying a roller bandage varies with the region to be bandaged. Its application to an extremity, however, is sufficiently illustrative of its use in general, and may be briefly described as follows :

Bearing in mind the amount of firmness and support required, and that the pressure must be evenly distributed over the part, the roller is seized with the right hand, the free end being detached with the thumb and fore finger of the left hand, the bandage unrolled for some three or four inches; the free end is then placed upon the inner side of the limb, and the roller carried around it again and again, each time overlapping the one preceded by about half its width. Where the extremity is cone-shaped the *reverse* must be employed, this being done by turning the bandage on itself. This process is repeated until the part again becomes cylindrical or until the region is sufficiently covered. When the bandage has been applied the remaining free end is pinned to the underlying layers.

Fig. 109.

Barton's head bandage as employed for suspension in applying plaster-of-Paris bandage.

The **triangular** or **scarf bandage** is simple, efficient, and of wide applicability: it has proven of great value in emergencies upon the battle-field and elsewhere.

Special bandages include the *many-tailed* H and T bandages, all of which are found useful in certain regions of the body, a few typical examples being shown in Figs. 107, 108.

CHAPTER XIX.

ANÆSTHESIA AND ANÆSTHETICS.

By H. A. Hare, M. D.

The word *ancœsthetic* was first suggested, as a suitable term for a drug which removed the sense of pain, by Oliver Wendell Holmes in November, 1846, the discovery of this property of *ether* or ethyl oxide having been put to practical application by Dr. Morton, a dentist of Boston, on September 30, 1846. The first public use of ether for surgical purposes was made by Warren on the 16th day of October, 1846, in the Massachusetts General Hospital. Although Long of Georgia caused anæsthesia by ether as early as 1842, and Jackson of Boston asserted that it was he who made the discovery, and not Morton, it has been decided by competent judges that the latter (Morton) really deserves the credit for the general introduction of ether as an anæsthetic for surgical purposes. In November, 1847, just one year after Morton's discovery, Simpson of Edinburgh first noted the anæsthetic power of *chloroform* on himself and some friends. Since this time no other substance designed to produce general surgical anæsthesia has been introduced which approaches the usefulness of these two drugs, and they remain the almost universal anæsthetics of the day, if we except nitrous-oxide gas, the applications of which are very limited.

Before discussing the action and uses of ether and chloroform it is proper to consider several general facts concerning both of them and the use of anæsthetics in general. The first fact to be borne in mind by the surgeon is that these drugs are not to be used except when really needed, and when employed are to be chosen with distinct ideas as to their individual peculiarities and indications in each case. A patient under the effect of so powerful a drug that consciousness is destroyed is nearer death than the ordinary human being, since the primary depressing influence upon the high nervous centres may speedily pass to the lower vital centres in the medulla oblongata.

Again, the day is fast approaching, if not already here, when the surgeon must choose the anæsthetic to be used in each individual, just as he directs one or another cardiac stimulant in circulatory failure according to the end to be obtained. No one should use ether exclusively or chloroform exclusively, for there are, as we shall point out later on, indications and contraindications governing the use of both.

Another point to be remembered is that the skill of the anæsthetizer does not consist so much in getting his patient under in a short time as it does in producing surgical anæsthesia *gently*, *easily*, and *tenderly*, so that the heart and mind will not be disturbed by suffocation, fright, struggling, or overdosing with the drug. Many anæsthetizers think that their responsibility ceases as soon as the patient returns to consciousness, but nothing is more erroneous, for much of the post-anæsthetic distress, the vomiting, the bronchitis, the pulmonary congestion, and the condition of anuria may be avoided by properly giving the drugs we are discussing.

It is quite as much a duty to avoid excessive drugging under these circumstances as it is to avoid overdosing when digitalis or any other powerful drug is used, for the skill of the physician consists not only in knowing what to give, but in knowing when enough has been used to produce the results sought for. The dose of the anæsthetic is to be governed by the response of the individual, and the physician who drowns his patient with chloroform or ether is producing poisoning and not therapeutic anæsthesia.

Every person to whom an anæsthetic is to be given should be *examined* to determine the condition of the *heart* and *blood-vessels*, and, if time permits, the *urine* should be examined repeatedly for several days prior to the operation to determine the condition of the kidneys, since the danger of artificial anæsthesia is greatly increased by the presence of disease of the heart, blood-vessels, or kidneys. Immediately before the drug is given careful inquiry should be made to discover whether the patient has some foreign body in the mouth, such as false teeth, tobacco, pins, or, as is frequently the case to-day, chewing-gum, which if not removed may cause grave difficulties by falling to the back of the mouth and so obstructing the air-passages. The patient also should be asked whether he or she has ever taken an anæsthetic before, and if so whether it had any untoward effect. In this manner idiosyncrasies may be discovered which will enable the physician to be on the lookout for accidents.

An anæsthetic should never be given without the consent of the patient or his friends if it be possible to obtain it, but in an emergency case, should no friends be at hand and the patient incompetent to decide for himself, then the surgeon may fearlessly take the responsibility of giving the drug he deems safest. Care should always be taken when a *woman* is to be anæsthetized that a reliable *assistant*, preferably a female nurse, is present, both for the comfort of the patient and for protection of the physician, since cases are on record where the patient has accused her medical attendant of assault while he had her under the effects of the drug, either for the purpose of blackmail or because in the anæsthetic sleep she has experienced an orgasm of which the anæsthetizer has appeared to be the cause.

Leaving for later on the discussion of the relative safety of the minor anæsthetics, we come to a study of the *safety* of ether and chloroform. There has been much difference of opinion as to the relative safety of these drugs, but at present the profession is practically a unit in recognizing that ether is the less dangerous by far, although a large number of eminent men still employ chloroform to the exclusion of ether, on the ground that when given with care accidents are almost unheard of. When we remember that in many cases the giving of the anæsthetic is entrusted to the least experienced professional man present or to a nurse, the relative danger of ether and chloroform is a factor of importance.

Deaths have occurred in only too many instances while patients have been under the influence of either drug, but it is a noteworthy fact that in nearly every instance where death has occurred as the direct result of the use of ether some abnormal condition of the patient precipitated the catastrophe. On the other hand, death due to chloroform has occurred frequently in those in the best of health in whom no trace of disease could be discovered.

Published statistics as to the relative safety of ether and chloroform during anæsthesia are open to many objections and vary with startling discrepancies, so that even the largest collections of figures are to some extent at fault. The chief fault is that in none of the statistics are the deaths really resulting from the direct action of the drugs separated

from those in which it has only needed the action of a powerful substance to upset the balance of function in some diseased organ and so produce a fatal ending.

The following table shows the approximate death-rate from ether and chloroform, and the variations in statistics according to different collectors:

	ETHER.	CHLOROFORM.
Andrews,	1 death in 23,204 cases.	
	1 death in 16,542 cases.	1 death in 5860.
Julliard,	(314,738 cases), 1 death in 14,987 cases.	(524,507 cases), 1 death in 3258.
Ormsby,	1 death in 23,204 cases.	1 death in 2873.
Roger Williams,	(14,581 cases), 1 death in 4860 cases.	(12,368 cases), 1 death in 1236.
Lee,	1 death in 23,204 cases.	
Medical News collection,	1 death in 16,677 cases.	1 death in 3749.
Coles,	1 death in 23,204 cases.	1 death in 2873.
Gurlt,	(42,141 cases), 1 death in 6020 cases.	(201,224 cases), 1 death in 2286.
Richardson,		1 death in 3000.
Ziegler, Vogel, Körte, and Esmarch,	no death in 2900 cases.	

In studying this table the fact must be constantly borne in mind that one or two cases of heart disease or advanced renal disease, causing "death from the anæsthetic," so called, may seriously alter the percentage, but the preponderance in favor of ether is so great as to settle the question of relative safety for ever.

It is only fair to state, in addition to these figures, that Ollier has collected 40,000 etherizations without a death, Poncet 15,000, Tillier 6500, and Chabot 730. Similarly, McGuire of Virginia claims 28,000 chloroformizations without a death, Von Nussbaum 40,000, and Lawrie of India about 30,000.

Having discussed the relative frequency of death from ether and chloroform, we pass to the consideration of the general effects produced by their use, and under these separate headings will be discussed the *minor untoward effects* caused by them. As ether is most largely used in America, we will speak of it first.

Ether.

Sulphuric ether is made by the action of sulphuric acid upon ethylic alcohol. When it is used for inhalation purposes the greatest care should be exercised to see that it is pure and concentrated. At 77° F. its specific gravity should be 0.714 to 0.717, and it should leave absolutely no residue on evaporation. Ether should boil at 98.6° F. if placed in a test-tube containing some broken glass, and if 10 c. c. of it are poured on blotting-paper, no odor should be left upon the paper after the ether is evaporated.

When ether is first inhaled, even when well diluted with air, it is apt to cause a sensation of *oppression* or even of suffocation, which can be overcome by gradually increasing the strength of the vapor and by the aid of the patient, who, if intelligent, will often voluntarily overcome his shallow breathing and take deep inspirations of air laden with the vapor.

This primary sensation of suffocation, with that which often comes on just as the patient is about to pass into unconsciousness, can nearly always be avoided, at least in part, by not giving the drug too freely, or rather by allowing enough air to enter with the vapor of the ether to prevent cyanosis.

Only in the most hurried cases is it proper to pour the ether on the inhaler and then hold it tightly over the patient's face at the very beginning of the administration. Not only is such a method harsh and calculated to frighten the timid, but it is capable of straining the heart through congestion arising from the struggles of the patient, and, if any weakness of the blood-vessels is present, may cause their rupture by the rise of arterial pressure produced by the drug, the struggling, and the partial asphyxia.

The direct cause of the primary arrest of respiration when ether is given has been proved to be irritation of the peripheral filaments of the trifacial nerve, which reflexly causes spasm of the glottis (Kretzschmar), and irritation of the peripheral vagi in the lungs, which inhibits respiratory movement and momentarily impedes the action of the heart (Hare). Probably there is also a spasm of the muscular fibres of the smaller bronchial tubes induced by the irritant vapor of the ether.

Very commonly there follows after this period of reflex irritation a few long-drawn breaths, and then fixation and immobility of the chest ensues, so that for thirty seconds or a minute it would seem as if the patient was *forgetting to breathe*, and then a deep respiration like a long-drawn sigh ensues, followed by a rapid, deep breathing, which, by reason of the large amount of ether inhaled, either renders the patient partially anæsthetic and ready for a minor and brief operation or more commonly it initiates what is known as the *stage of excitement*, during which the patient shouts, sings, cries, swears, or fights, according to his temperament and previous condition. This stage rarely lasts for more than a few minutes, and then the patient actually passes into the complete anæsthetic condition and is ready for the surgeon's method. The *pulse* from the first under ether is *accelerated*, although in some cases, where because of fright or other reason the pulse has been very rapid, it may be slowed by the steadying or stimulant effect of the drug. The *respirations* when once the patient is anæsthetized are more *rapid* and *deeper* than in health, and the skin is dry and warm, though often flushed, particularly about the face and neck.

As the etherization proceeds the respirations return to the normal rate or fall a little below it, and if the effects of the drug are excessively marked, they become slower and more shallow than in health, while the face, heretofore flushed, may become exceedingly pale, or if the ether is given in too large amount and with too little air the patient may become cyanotic.

With the development of well-marked muscular relaxation *snoring* or *stertorous breathing* comes on, and the increased secretion of mucus and saliva due to the irritant effects of the ether increases the noisiness of the respiratory cycle. If the ether be pushed beyond all therapeutic bounds, the pallor of the surface changes to a deathly lividity, while the skin becomes cold and perhaps relaxed and moist, the pulse fails; the respiration is gradually extinguished from intoxication of the respiratory centre, so that death ensues from this cause. The muscular system is totally relaxed and flabby, but the heart continues to beat feebly for some moments after the breathing ceases. In producing its effects ether *depresses first the perceptive and intellectual cerebral centres, next the sensory side of the spinal cord, next the motor side of the cord, then the sensory and motor portions of the medulla oblongata; and with this depression death ensues.*

Turning from the general effects produced by ether to its therapeutic application, we find that it has certain *advantages* and *disadvantages*.

The chief advantage connected with its use is that it is by far the safest anæsthetic substance so far discovered for the production of anæsthesia during prolonged surgical operations. The patient passes under its effect, as a rule, quite rapidly, and once anaesthetized needs but a small additional quantity to keep him under its influence.

Besides the lethal effects of ether we have still before us a consideration of the *non-fatal accidents* which may occur under its influence and the *sequelæ* which follow its use. The *accidents* which occur during the use of ether are rarely very alarming, and consist chiefly in *arrest of respiration* through depression of the respiratory centre by the excessive action of the drug, or *stoppage of breathing* caused by an accumulation of mucus or some foreign body in the air-passages. The appearance of the face must be the guide under such circumstances as to the methods of relief to be employed. If the face is, as usual, very much flushed or dusky or *cyanotic*, *artificial respiration* is to be resorted to by the general methods described later in this article under the treatment of anæsthetic accidents. If it is very *pale*, thereby indicating cardiac as well as respiratory failure, then the artificial respiration should be aided by *inversion of the patient* and the injection of *stimulants*.

The *sequelæ* following etherization are chiefly pulmonary and renal, and it is probable that a certain number of deaths result from these secondary manifestations of the action of this drug. As will be pointed out when discussing the choice of an anæsthetic, *bronchitis*, *pulmonary congestion*, and *catarrhal pneumonia* often seem to be produced by it. Very rarely, even croupous pneumonia has ensued.

Renal disorders from the use of ether rarely arise in persons with primarily healthy kidneys, and consist in varying degrees of irritability and inflammation up to that which results in the condition of *anuria*, which is the most serious and fatal complication which can arise, because death is nearly always assured by this symptom, and because it is practically irremediable.

The question as to whether ether really does irritate the kidneys has been studied both clinically and experimentally, and it seems certain that if the drug is continuously given for a long period of time, it may develop cloudy swelling of the cells in the normal kidney and actual incompetency in kidneys already diseased. In Weir's studies on this subject it was proved that albuminuria might be produced in kidneys previously perfectly sound by inhalation of ether for surgical purposes, but that this was rarely the case. Similar testimony as to the fact that ordinary uses of ether do not irritate the perfectly healthy kidney is to be found in the studies of Reuter, Garré, Butter, and Körte, but there is plenty of evidence that in the presence of renal disease it causes in many cases serious disorders. Further than this, nearly all surgeons in looking up this question have regarded the presence or absence of albuminaria as the crucial test of renal integrity, whereas we now know that a much more accurate guide is an estimation of the amount of urea excreted. Until this estimation is made in a large number of cases this point cannot be positively decided, for, in opposition to the statements made above, Deaver found evidences of renal irritation quite constantly, and Blake states that in 36 cases out of 50 ether either produced albuminuria or augmented it.

The use of ether in the case of diabetics is dangerous, and Becker has found in 188 cases of etherization acetonuria in no less than two-thirds. Baxter has reported a death from ether given to a diabetic, who passed into coma from the anæsthetic state.

An important fact in this connection with the development of catarrhal complications after ether is that surgeons, as a rule, are careless of the *maintenance of the body-temperature* during an operation. In a series of studies made by the writer some years since it was found that even under brief operations the temperature might fall from 1° to 4° F., this fall being due in part to the evaporation of the ether and to the depression of the vital processes. Naturally, irritation of the respiratory mucous membrane plus exposure to cold will predispose to pulmonary complications, and the chilling of the surface produces pulmonary and renal congestion.

Vomiting following the use of ether is unfortunately very commonly seen, and is practically a constant sequel in those who have inhaled the drug upon a full stomach. It is supposed to be due to irritation of the vomiting centre and to the swallowing of saliva and mucus. It is to be avoided to some extent by giving the drug on an empty stomach. Once developed, the vomiting is to be treated by *counter-irritation* in the form of a mustard plaster over the epigastrium, by the use of one-grain doses of *acetanilide* every hour,[1] or by *rectal injections of bromide of sodium and laudanum* in starch-water. Sometimes washing out the stomach with a stomach-tube gives relief. For persistent singultus drachm-doses of Hoffman's anodyne are very effective.

Chloroform.

This drug was discovered practically simultaneously by Guthrie in America and Soubeiran in France. It is a colorless, transparent, volatile fluid of a hot sweetish taste and rather pleasant odor, having a specific gravity of 1.491 at 60° F. It is liable to decomposition in the presence of sunlight, and generally contains about 1 per cent. by weight of alcohol to retard this change. A pure chloroform has been made by a freezing process by Pictet, which is said to be less liable to decomposition than that made by the ordinary method. Great importance is to be attached to the use of pure chloroform, as many of the fatal accidents are believed to be due to the use of a poor article. It should be absolutely neutral, and when evaporated in a watch-glass should leave no residue of any kind or any strong odor.

When chloroform is inhaled by the healthy man there may be for a moment a slowing of the pulse and a rise of arterial pressure, due in part to the cerebral excitement of the patient and to the irritation of the respiratory mucous membrane produced by the anæsthetic vapor, which may also reflexly cause cardiac inhibition. This condition is, however, very fleeting, and is replaced by a pulse *more rapid* than normal and one which is *less powerful*. The arterial tension is generally *decreased*. The *respiration* may for a very brief period be partially arrested, but this symptom is often entirely absent, and never so marked as when ether is given.

The *pupils* are primarily a little dilated, but permanently contracted during full anæsthesia. *If they suddenly dilate during the anæsthetic period, death is imminent.* In other words, relaxation of the iris under chloroform is a part of the relaxation of death.

[1] A very useful formula in this connection is one composed of 1 grain of acetanilide, 1 grain of monobromated camphor, and 1 grain of citrated caffeine, given every hour for six or eight doses.

Should the patient struggle violently, the drug must not be pushed, and it is to be borne in mind that the use of the drug is more apt to cause sudden death if the patient be an *athlete* or a *drunkard*.

The action of the chloroform in producing anæsthesia is identical with that of ether, acting first on the perceptive centres, then on the intellectual centres, and then on the motor centres. Care should also be taken while it is being used that the bodily heat does not fall.

The effect of chloroform on man and lower animals has been studied with extraordinary care all over the world, and much conflicting testimony exists concerning it. The writer has embodied his views as to its safety in his report to the Governor of Hyderabad, India, and believes that the medium ground there taken is the correct one; and it is an interesting fact that Randall and Cerna of Galveston undertook a series of studies designed to contradict these conclusions, but in the end endorsed them.

The writer very positively asserts that chloroform practically always kills by *failure of respiration* when administered by inhalation up to the point of producing poisoning, provided—and this provision is most important—that the *heart* of the anæsthetized *is healthy* and has not been rendered functionally incompetent by fright or violent struggles, or, again, by marked asphyxia. There can be no doubt that chloroform always impairs the circulation by causing a fall of blood-pressure by its depressant effect on the vasomotor system and upon the heart, and for this reason any idiosyncrasy or disease might readily result in a cardiac death from it.

In other words, supposing that the amount of depression from very full doses of chloroform equals 25 units, this amounts to little in the normal heart; but if the heart be depressed 25 additional units by disease, the depression of 50 units may be fatal, particularly if to this 50 is added 25 units more of depression through fright and cardiac engorgement arising through disordered respiration or struggling. That true depression of the heart-muscle may take place under chloroform seems most undoubted, for there is always a decrease in cardiac power manifested by the decrease in the force of the individual pulse-beat under its influence.

The *accidents* which may result during the use of chloroform will be discussed under the head of the Treatment of Accidents under Anæsthetics. We shall now speak of the sequelæ which may follow the use of chloroform. The most important of these is renal disorder, for pulmonary complications are very rare indeed.

In a recent series of clinical investigations Wunderlich has thrown doubt upon the advisability of using chloroform for patients with *renal disease*, claiming that it is capable of causing disastrous congestion and irritation of the renal structures. Still more recently Alessandri has stated that, while the effects of chloroform upon healthy kidneys are practically *nil*, in patients with renal affections this condition of perfect safety cannot be said to exist, and he believes, further, that chloroform under these circumstances is to be avoided if possible, and that prolonged or repeated anæsthesias by it in such cases are unjustifiable.

The truth of the matter seems to be that both ether and chloroform possess the power of distinctly irritating the kidneys, but it also seems to be undoubtedly true that, as chloroform acts as an anæsthetic in very small quantities, it is always to be the anæsthetic of election where operative procedures are demanded in the face of renal complications.

Vomiting following the use of chloroform is comparatively rarely seen, although nausea may be present in susceptible persons.

Ethyl Bromide.

The position of bromide of ethyl as an anæsthetic is still undecided. Originally introduced with much promise, it soon fell into disrepute because of several deaths which took place under its use, but within the the last few years it has been more largely employed, notably by Montgomery of Philadelphia.

In cases where enough of it is given to produce death in one of the lower animals the fatal result depends upon respiratory failure. In man we have no reliable records as to its method of causing death, but there seems to be little doubt that the heart may be seriously disturbed in its action by the drug, although the writer believes that the respiratory function is the one most affected.

The *advantages* possessed by ethyl bromide are its speedy action, the patient becoming anæsthetic in a very few moments, and the equally rapid passing away of its effects, the patient returning to consciousness almost at once when the drug is removed. Other advantages are that it produces no disagreeable after-effects. Generally the patient is able to walk perfectly in a very few minutes without much vertigo or nausea. Sometimes during its inhalation tonic spasm of the muscles with rigidity develops.

The *proper manner of using bromide of ethyl* is to pour two or three drachms on a well-made ether cone, and then to give as pure vapor of the drug as possible, with little air. If much air enters, the anæsthesia is imperfect and the operation of the drug unsatisfactory. Sometimes, even if the drug be well given, a temporary tonic contraction of the muscles comes on and is more or less persistent.

There are several points of great importance to be borne in mind about this drug. The first is that it is only suitable for brief operations lasting a few minutes, like opening an abscess or curetting the uterus. The second point is that it must be absolutely pure. Poured over the hand and allowed to evaporate, it should leave no oily smell, and it must be kept in dark tightly-stoppered or hermetically-sealed bottles. It is best to buy it in small glass vials which have been closed by melting the glass and which contain about enough for one operation. If exposed to light or air, it decomposes and becomes dangerous.

Bromide of ethyl is not to be confused with *bromide of ethylene*, which is very poisonous.

A. C. E. Mixture.

Various mixtures of chloroform and ether have been made and used for the production of anæsthesia. The most commonly used of these is the so-called "A. C. E. mixture," composed of *alcohol*, *chloroform*, and *ether*. It was thought that, as alcohol and ether stimulated the heart and chloroform depressed it, a combination of the three drugs would antagonize each other on these vital points while acting to produce anæsthesia. Unfortunately for this theory, the drugs differ so in volatility that they are not absorbed simultaneously in equal amount, and the alcohol tends to produce bronchial irritation and prolonged intoxication. The mixture is not to be commended.

Nitrous-oxide Gas.

This gas is the safest and most rapid general anæsthetic that we possess. As its anæsthetic influence does not last more than a minute, and

in many persons not more than fifteen to thirty seconds, it can only be used for very brief minor operations, and as a matter of fact is seldom used except by dentists for the production of anæsthesia during the extraction of teeth.

When the gas is given to man there may be a momentary increase in sensitiveness, followed by analgesia, during which time little feeling exists, although the patient generally knows what is being done. Immediately after this he becomes absolutely unconscious and jerking or twitching of the muscles may occur. The superficial reflexes are abolished, but the knee-jerk is present and ankle-clonus is often present. Often the bladder and rectum are emptied, but vomiting rarely occurs. The subsequent symptoms are tinnitus aurium, headache, and dimness of sight.

Sometimes nitrous oxide is used to anæsthetize a patient when the surgeon is in a hurry, unconsciousness being then preserved by the additional use of chloroform and ether.

Nitrous oxide ought not to be given to persons with fatty heart or atheromatous vessels.

The Choice of an Anæsthetic.

As already stated, ether and chloroform are still the anæsthetics of election for all general purposes. Nitrous oxide is only suited to minor and brief operations, and is difficult of use because of the bulk of its containers: the other anæsthetic substances are either dangerous or, like ethyl bromide, only suited for the production of rapid passing effects.

(1) On general principles ether is to be preferred to chloroform, whenever no contraindication to its use exists, because of its greater safety. This is particularly the case where an inexperienced person is to give the anæsthetic. It is, however, *inferior* to chloroform in very *young children* and in persons who have *bronchitis*, because of its irritant effect on the respiratory mucous membrane. *Renal disease* also renders ether a dangerous anæsthetic, because the kidneys are irritated by it, and, again, marked atheroma or aneurism contraindicates its use, since it greatly increases arterial pressure and so tends to produce arterial rupture.

Similarly, it will be found best not to attempt the use of ether in hot climates, because of its volatility, nor on the battlefield, where rapidity of action is essential and where its bulk is so great as to make its use difficult.

Ether should *never* be given in the presence of a *naked flame*, unless the flame be high above the cone, as the vapor is inflammable. The vapor of ether being heavier than air, gravity causes it to sink to the floor.

(2) *Chloroform* is not as safe as ether for the average case, but is to be preferred, where ether cannot be used, to any similar drug. It is to be preferred in hot climates (where ether is inapplicable), and here a free circulation of air increases the safety of the patient. It may also be selected whenever a large number of persons are to be rapidly anæsthetized, so that the surgeon may pass on to others and save a majority of lives, even if the drug endangers a few, as on the battlefield, where only a small bulk of anæsthetic can be carried.

(3) Its employment is indicated in cases of *Bright's disease* requiring

the surgeon's attention, owing to the fact that anæsthesia may be obtained with so little chloroform that the kidneys are not irritated, whereas ether, because of the large quantity necessarily used, would irritate these organs. *Quantity for quantity, ether is of course the less irritant of the two.*

(4) In cases of *aneurism* or pronounced *atheroma* of the blood-vessels, where the shock of an operation without anæsthesia would be a greater danger than the use of an anæsthetic, chloroform is to be employed, since the greater struggles caused by ether and the stimulating effect which it has on the circulation and blood-pressure might cause vascular rupture.

(5) In *children* or adults who already have *bronchitis*, or who are known to bear ether badly—or, in other words, have an idiosyncrasy to that drug—chloroform may be employed.

(6) Persons who struggle violently and who are robust and strong are in greater danger from the use of chloroform than the sickly and weak, probably because the struggles strain the heart and tend to dilate its walls.

In operations upon the *nose or throat* chloroform is the best drug to employ, as by its use vomiting is avoided, only small quantities are needed to keep the patient under its influence, and the operator can readily examine the area of his operative procedures. Similarly, in some cases where vomiting following upon thoracic or abdominal operations is greatly to be feared chloroform is to be preferred to ether.

Because of its rapidity of action chloroform is largely used to the exclusion of ether during *labor*.

From the time at which chloroform was first introduced into medicine as an anæsthetic until to-day it has been universally recognized that parturient women seem to possess an immunity to its poisonous properties; and it is one of the curiosities of medical literature that while the journals fairly teem with reports of chloroform deaths when the anæsthetic has been given for ordinary operations, death from this drug in parturient women is almost unknown. Various explanations have been put forward by obstetricians and others as to the reason of this apparent immunity.

It seems to us that the correct explanation of the ability of parturient women to take full amounts of chloroform without accident arises in the well-known influence which is exercised by pain upon the vasomotor centres. Whatever may be the differences of opinion in regard to the influence of chloroform upon the heart, every investigator so far has admitted that its primary influence is upon the vasomotor centre, and every physiologist knows that complete vasomotor paralysis is capable of producing death if at the same time the respiration and heart be somewhat depressed.

In the physiological laboratory it is customary to irritate a sensitive nerve whenever it is desired to decide as to the integrity of the vasomotor centre; or, in other words, pain produces a rise of arterial pressure by stimulation of this centre. We believe that the immunity of parturient women to chloroform depends upon the fact that frequently repeated labor-pains continually stimulate the vasomotor centre, and so antagonize the depressant influence which is exercised by chloroform upon this important portion of the nervous system. Certainly it would seem very probable that this explanation is the correct one, and we are confident that if the physician will feel the radial pulse of the patient at the time of the onset of any severe pain, he will find that arterial pressure is greatly increased.

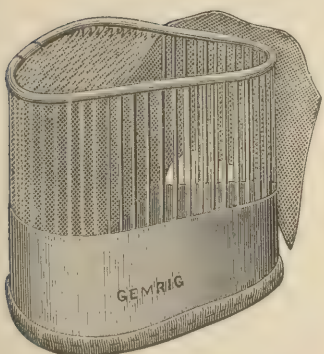
As typical examples of the effect which pain produces in the human being in this respect we may cite the hard, corded pulse of acute peritonitis or the equally high-tension pulse of lead, renal, or hepatic colic.

Administration.

We have already referred to the necessity of giving anæsthetics gently and in not too concentrated form. *Ether* is best given by means of one of two *inhalers.*

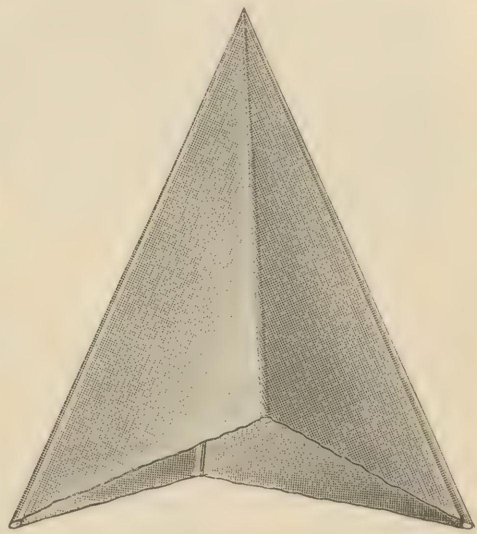
The first is that of Allis, which is designed to give the patient plenty of air heavily laden with ether vapor. It consists of a wide collar-shaped piece of leather with a fenestrated metal lining, through the openings of which is passed from side to side a wide roller bandage. The ether is poured on these diaphragms, and the air passes over them, becoming heavily charged with the evaporating ether. (See Fig. 110.)

Fig. 110.



Allis's inhaler (from Lentz).

Fig. 111.



Lawrie's inhaler, consisting of four bamboo sticks, supporting unbleached muslin.

A simple and readily-made inhaler for ether is made by shaping a towel, containing between its folds a stiff piece of paper, into a cone or cornucopia, in the apex of which is placed some absorbent cotton or a small sponge. Upon this cotton is poured the ether, and the large open end of the cone is placed over the patient's face. If well made, this is a very satisfactory inhaler which can be hastily prepared for each case.

Other ether-inhalers exist by the score, but nothing is gained by using them.

Ether should be so freely given that the air is only present in about 5 per cent. while the patient is struggling, *thereby differing from chloroform, which ought always to be given with about 95 per cent. of air.*

For the inhalation of *chloroform* the safest method of administration is by Lawrie's or Esmarch's inhaler, because these provide free circulation of air and do not distract the attention of the anæsthetizer from the respiratory movement by complicated apparatus. Apparatus much like these in allowing a free amount of air are the Hyderabad chloroform-

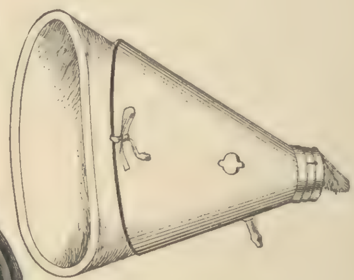
inhaler or open-ended cone, with Krohne and Seseman's respiration-indicator attachment.

The Junker inhaler, even with its modifications, is too complicated

FIG. 112.

Esmarch's inhaler and chloroform bottle. The inhaler consists of a wire frame covered by a thin piece of flannel.

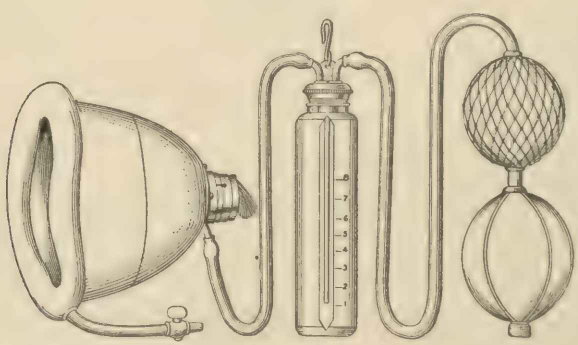
FIG. 113.



Krohne and Seseman's modification of Lawrie's inhaler, with respiration-indicator attached. The inner lining is white felt, the outer case is leather. It can be used directly or by the air-pump attached to the top.

and cumbersome, and, while less chloroform is wasted in administering the drug, it must all be thrown out of the bottle afterward. If used at all, it should be used with the increased air-supply and respiration-indicator of Krohne and Seseman.

FIG. 114.



Krohne and Seseman's modification of Junker's inhaler, with respiration-indicator.

A very useful addition to our methods of producing anæsthesia by ether and chloroform is the administration of oxygen gas by inhalation with the anæsthetic vapor. By this means cyanosis is less likely to come on, accidents are more rare, and it is claimed that vomiting is often entirely avoided. It has been suggested that the mixture of oxygen with the vapor of these drugs may produce some chemical changes,

but this view is incorrect. The mixture of ether vapor and oxygen simply forms a high explosive mixture. If ozonized ether is conducted into anhydrous ether, it forms a thick liquid which explodes if heated.

FIG. 115.

Oxygen apparatus for use in producing chloroform or ether anæsthesia. The oxygen gas passes through the anæsthetic in the bottle, and so becomes laden with the vapor.

It is probably ethyl peroxide. Chloroform when mixed with oxygen undergoes no change.

If one of these inhalers is not employed, the chloroform is to be given by letting it fall drop by drop on a folded napkin held far enough away from the face to permit the inhalation of 95 per cent. of air with 5 per cent. of chloroform vapor. This free supply of air is important, whether we believe death to be imminent from cardiac or respiratory failure; but this supply of air matters little to the patient if he does not breathe freely, nor does the dose of chloroform amount to aught if it is not drawn into the chest. The dose of chloroform is not the amount on the inhaler, but the amount taken into the chest, and, finally, the amount absorbed by the blood-vessels. We agree so heartily with Lawrie's personal conclusions as to the manner in which chloroform is to be used that we print them below:

1. Chloroform should be given on absorbent cotton stitched in an open cone or cap.

2. To ensure regular breathing, the patient lying down, with everything loose about the neck, heart, and abdomen, should be made to blow into the cone held at a little distance from the face. The right distance throughout the inhalation is the nearest which does not cause struggling or choking or holding of the breath. Provided no choking or holding of the breath occurs, the cap should gradually be brought nearer to, and eventually may be held closer over the mouth and nose as insensibility deepens.

3. The administrator's sole object while producing anæsthesia is to keep the breathing regular. As long as the breathing is regular and the patient is not compelled to gasp in chloroform at an abnormal rate, there is absolutely no danger whatever in pushing the anæsthetic till full anæsthesia is produced.

4. Irregularity of the breathing is generally caused by insufficient air, which makes the patient struggle or choke or hold his breath. There is little or no tendency to either of these untoward events if sufficient air is given with the chloro-

form. If they do occur, the cap must be removed and the patient must be allowed to take a breath of fresh air before the administration is proceeded with.

5. Full anæsthesia is estimated by insensitiveness of the cornea: it is also indicated by stertorous breathing or by complete relaxation of the muscles. Directly the cornea becomes insensitive or the breathing becomes stertorous the inhalations should be stopped. The breathing may become stertorous while the cornea is still sensitive. The rule to stop the inhalation should, notwithstanding, be rigidly enforced, and it will be found that the cornea always becomes insensitive within a few seconds afterward.

It is only necessary to add that the patient should be so dressed for an operation that his respiratory movements can be easily seen by the chloroformist.

The use of chloroform requires that it shall be used only in the *purest form*, as medical literature shows that *impure* chloroform is very *dangerous* to life. Care should be taken that chloroform is not given in a room where there is a burning gas-jet unless there be good ventilation, as it is decomposed by the flame, setting free irritant fumes of chlorine, and thereby causing respiratory inflammation.

Accidents from Anæsthetics.

There still remain to be considered the methods which we are to resort to in accidents under anæsthetics. First, let us discuss the treatment of *arrested respiration*. This should be treated by the use of the

Fig. 116.

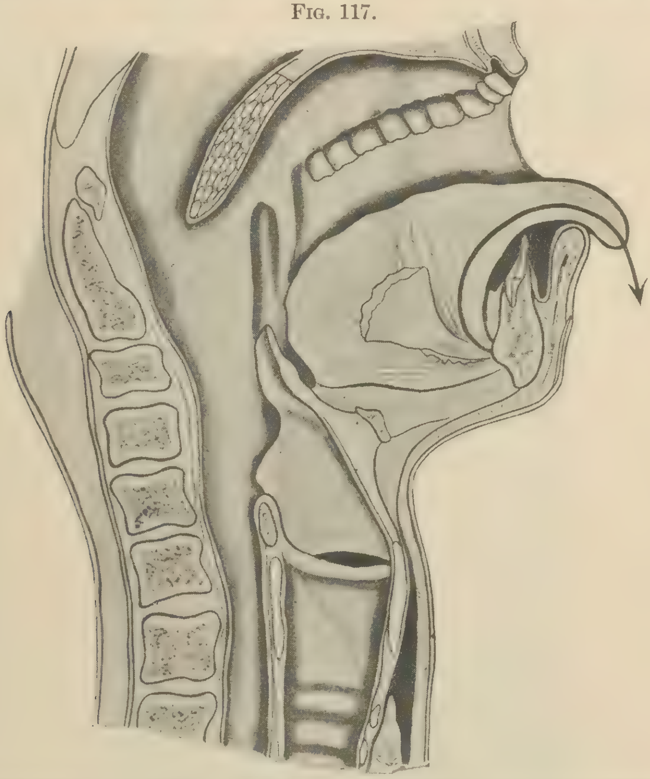
Cut showing how proper traction on the tongue pulls on the epiglottis.

Sylvester method, as by this means a greater amount of air enters the chest than by any other. For the free entrance of air we must so place the head that the epiglottis and tongue will not obstruct breathing.

As long ago as 1889, Howard of London published a very interesting paper on this topic, which has since been widely quoted. While recognizing the value of his studies, a series of studies made by Martin and the writer have led us to reach somewhat different conclusions in regard to the posture of the head and its influence on the patulousness of the windpipe. Howard's statements in regard to the rôle of the epiglottis in cases of arrested respiration in anæsthesia are as follows:

1. The epiglottis falls backward in apnœa and closes the glottis; therefore the first thing in order and importance is the elevation of the epiglottis.
2. Traction upon the tongue, however, whatever the force employed, does not and cannot raise the epiglottis, as supposed.
3. The epiglottis can only be raised by the extension of the head and neck.

Fig. 117.



Cut showing how dragging the tongue over the teeth fails to pull on the epiglottis.

The question which naturally arises first is, Is Howard correct in regarding the epiglottis as the cause of the obstruction? Personally, we believe he is wrong, because in the great majority of cases the air-passages are at once cleared of obstruction simply by drawing the tongue forward—a method resorted to by all of us, yet one which, as Howard himself states and as we have proved, has absolutely no effect on the epiglottis unless the traction is applied well back on the dorsum of the tongue by a tenaculum, or it is pulled forward and upward. We may conclude, therefore, that the epiglottis is not the chief cause of the obstruction, and that the tongue is more frequently at fault; but as any obstruction is undesirable, and as the epiglottis does sometimes certainly close the windpipe,

what shall be done to govern its position? Howard states that this may be accomplished solely by the posture of the head. The method which he recommends is as follows:

"Having, by bringing the patient to the edge of the table or bed or by eleva-

FIG. 118.

The head should be held as in this cut, extended, and pushed forward in the posture in relation to the trunk of that assumed by a runner.

tion of the chest, provided that the head may swing quite free, with one hand under the chin and the other on the vertex steadily but firmly carry the head backward and downward: the neck will share the motion, which must be con-

FIG. 119.

Showing the inversion of the patient as adopted by Kelly, and the method of performing artificial respiration simultaneously.

tinued till the utmost possible extension of both head and neck is obtained. Sometimes a slight elevation and extension of the chin will at once check the stertor or irregularity of breathing; but, understand, the extension, which can in

no case do harm, should always be rather more than appears necessary. It should never be forgotten, however, that the full effects of extension as above described can be secured with certainty only by making the extension complete as directed."

Once more, the studies which we have made of this subject have convinced us that Howard's advice is not practically valuable. Although there can be no doubt that the changes described are produced, so far as the position of the epiglottis is concerned, on the other hand such a position of the head and neck as he directs has the effect of strapping the soft palate over the dorsum of the tongue, thereby cutting off the entrance of air through the mouth and rendering the nostrils the only path for its entrance. As the nasal cavities are in many persons obstructed by exostoses, hypertrophies, or polyps, the nostrils do not afford a sufficiently certain entrance-space for air, and the removal of glottic closure by this posture may cut off the air higher up.

If, on the other hand, the head is extended and simultaneously projected forward, both the tongue and epiglottis are raised, and the soft palate is so drawn as to permit of free breathing through the mouth as well as the nose. This is well shown in the accompanying cuts.

Often in cases of circulatory failure during anæsthesia complete inversion of the patient may be practised with good effect, as seen in the accompanying cuts, taken from photographs of Dr. Kelly's method (Figs. 119 and 120).

FIG. 120.

Same as Fig. 119.

For the *cardiac failure* which comes on in cases of anæsthesia the best drug we can employ hypodermically is *strychnine* in full doses, at least $\frac{1}{20}$ grain, repeated in ten minutes if need be, and associated with $\frac{1}{100}$ grain of *atropine* sulphate, since it has been proved that strychnine

is the best physiological stimulant to respiration and the heart that we have, while the atropine aids its influence on these functions and stimulates the vasomotor system.

When an accident occurs under chloroform, this medication is particularly necessary, for, as already pointed out, the influence of chloroform on the blood-vessels is its primary and dominant effect.

This influence the author believes to be very much more worthy of attention than is generally recognized. Every physiologist knows that the action of the heart and respiration is greatly influenced by vasomotor relaxation. The gasping respiration of sudden faintness is probably due more to sudden vascular dilatation than to direct failure of the heart, and the exceedingly rapid pulse of shock is seen in conjunction with the relaxed blood-vessels so characteristic of this state. The integrity of the vasomotor system is as necessary to life as the integrity of the heart, since it is under the government of this system that the cardiac mechanism is active and the vital interchanges take place throughout the body. Acting upon this belief, the writer has found, both in the laboratory and at the bedside, that atropine enables more chloroform to be given without circulatory depression than can be used if no atropine is administered, and there is good reason to believe that the use of atropine by surgeons for the purpose of stimulating the respiratory functions or preventing cardiac inhibition by irritation of the vagus in reality prevents dangerous symptoms, chiefly by its vasomotor influence.

Of the methods of *artificial respiration*, Sylvester's is by far the best, as it drives more air into the chest, or, in cases where this cannot be done, we should not forget the very remarkable results to be obtained by practising Laborde's method of *rhythmical traction on the tongue*. The tip of the tongue being grasped, it is drawn out of the mouth regularly sixteen times a minute, and, probably by reflexly stimulating the respiratory centre, *renews respiratory movements* in apparently hopeless cases.

The application of *electricity* in the presence of circulatory or respiratory failure during anæsthetization rests entirely upon its power to produce irritation of the peripheral sensory nerves, thereby reflexly causing respiratory effort. The idea that placing one pole over the phrenic nerve in the neck and another over the diaphragm will cause this muscle to carry out the respiratory movement is *incorrect*. As a matter of fact, Martin and the writer have proved that this effect is never produced, but, on the other hand, that it is possible to produce so much irritation of the vagus that temporary inhibition of the heart may result—a serious condition if that organ is already depressed. If electricity is used for the purpose of producing resuscitation, the poles should be swept over the skin to cause pain and reflex stimulation.

Local Anæsthesia.

The production of local anæsthesia is sought for either through the influence of *cold*, which benumbs the nerve-endings or trunks, or by the use of *cocaine* or *carbolic acid*, which paralyzes peripheral sensory nerves when it is brought in contact with them.

The *advantages of local anæsthesia* in minor operations are manifest. When cold is used, we can employ a small piece of ice dipped in salt, or a *spray of chloride of ethyl* or *chloride of methyl or rhigolene*. The chlorides of ethyl and methyl as commonly employed are contained in glass bulbs the ends of which taper to a point. This point having been broken off, the heat of the hand forces a fine spray of the liquid out of the glass, which as it strikes the skin becomes volatilized and simultaneously freezes the surface. The skin becomes blanched, then shrivelled and hard to the touch. After the anæsthesia, which lasts for a

few moments, is over, the part becomes pink and remains congested in appearance for some hours. Rhigolene or ether may be used in an ordinary fine atomizer.

Aside from cold, we most commonly use **cocaine** for local anæsthetic effects. As this drug cannot penetrate the skin, it can be applied only to mucous membranes, unless we introduce it under the skin by means of a hypodermic needle. The strength of solution of cocaine for mucous membranes varies with the membrane to which it is to be applied. Thus in the eye a 2 per cent. solution is often strong enough. In the nose from 2 to 4 per cent. solutions may be used, whereas for the proper anæsthetization of such dense membranes as are found in the vagina and rectum 10 per cent. solutions may be needed. The application of cocaine to the ocular, vaginal, and rectal mucous membranes is almost never followed by untoward symptoms, but when applied to the nasal or urethral mucous membrane it may be rapidly absorbed and produce profound collapse. The application of cocaine to the urethral mucous membrane is peculiarly dangerous, sudden death having followed its use in this area. Very weak solutions should be employed in small amounts in the urethra for this reason.

When anæsthesia of parts protected by the skin is to be obtained, the drug in 4 per cent. solution may be injected under the skin very gently. Schleich has lately introduced a method of using a solution of 2 parts cocaine muriate, $\frac{1}{4}$ part morphia muriate, 2 parts sodium chloride, in 1000 parts of sterilized water, which is *deposited* in many beads or separate drops, the tissues being *infiltrated* or *distended* with the fluid. By using a sufficient quantity of the solution (even a weaker one being useful) extensive operations can be done without pain and without danger.

Local anæsthesia of the **skin** for minor operations may be obtained by *drawing a camel-hair pencil wet with carbolic acid* over the line in which the incision is to be made.

CHAPTER XX.

SURGICAL DIAGNOSIS.

By Chauncey P. Smith, M. D.

The chief reason for the practice of surgery is its purpose to relieve or cure disease. To obtain this end a recognition of the morbid process is always desirable and oftentimes more important than the treatment. With diagnosis comes more of the science and less of the art of surgery.

The lives of patients lie more in the hands of the general practitioners than in the hands of the surgeons, and there is no surgeon who has not seen many cases brought by family physicians with some unrecognized disease, far—perhaps too far—advanced for operative treatment, while if some operative procedure is to be done, it is with greater danger to life and at the expense of some mutilation or loss of some function. Too many women die yearly from carcinoma of the breast which goes unrecognized until too late for any hope for thorough removal. Too many children are crippled through ignorance and lack of systematic examination by physicians who call pain in the knee from hip disease "growing pain." Many students and younger medical men have a chance to make a diagnosis, but few to remove a jaw, yet their credit as regards the ultimate result should equal that of the operating surgeon.

It is well for the student to make a systematic, thorough, and methodical examination of every patient. He will have a knowledge of that case which will give him a better insight into its treatment, while he will gradually learn what is normal, and hence speak with some weight on what is abnormal or diseased. He will thus become familiar with joints, chests, malformations, diatheses, and many diseased conditions foreign to that one for which the patient comes. It will train him for close observation, and, furthermore, many times enable him to bring into play preventive medicine—*i. e.* the treatment of the future.

Much may be learned of the patient—his habits, his strength, malformations, diseases, etc.—from inspection. To be thorough, one notes the expression, whether of pain, apathy, or paralysis, and one may often judge of the patient's occupation and general condition.

External Examination.—When the patient is seen, observe his general appearance, whether robust or feeble. Note the color of the face—*e. g.* the florid face of plethora, the green of chlorosis, the paleness from anæmia, whether constitutional or due to hemorrhage, the sallow or yellow hue seen in septicæmia and hepatic disorders, the waxy skin of Bright's, the cyanosis due to obstructive respiratory or circulatory disease, the crimson flush of pneumonia and erysipelas. The color of the conjunctiva is as important—*e. g.* the paleness seen in anæmia,

the yellow of jaundice, the watery eye of the alcoholic, the glassy eye of cachexia. It should be observed particularly for hemorrhage when there is a history of injury, which, if subconjunctival, denotes serious intra-cranial mischief. In females note the presence or absence of cloasma, which occurs in pregnancy and during the menstrual periods.

The Eye.—General protuberance or exophthalmos is seen in *tumors* involving the antrum and brain. If this symptom be coupled with enlargement of the thyroid and irregular heart, the diagnosis of Basedow's disease is simple. *Conjugate deviation* is seen in apoplexy. The *pupil* is contracted to a pin-point in opium-poisoning; inequality is observed in brain-tumors, fracture of the skull, or some interference with the sympathetic nerve, such as carotid aneurism. A bright eye is seen in fever, coma-vigil in the typhoid state; the presence of the arcus senilis denotes arterio-capillary fibrosis. *Puffiness* is seen about the eyelids in nephritis, in inflammations near by, and in chronic alcoholics.

The Head and Face.—*Baldness*, usually partial, of the eyebrows, moustache, or hair is common in lues. It is also seen at the back of the head and in rickets, and is then due to restlessness. *Scars* about the face denote some previous injury or disease. Their presence is important in epilepsy: if about the angle of jaw, tuberculosis is usually the cause; if on the lip, syphilis, although the primary lesion of lues may be found at the alæ of the nose and inside the mouth, particularly on the tonsil and soft palate; if suspected, examine the contiguous lymphatic nodes. *Sweating* is a symptom in pyæmia, in rickety children—particularly at night—and in uræmia. In the latter the sweat has a urinous odor. The *real age* may be judged by the face, as well as the apparent age. By this is meant the real age from the life led, whether of overwork, anxiety, or dissipation. Observe the general contour of the head and face, the symmetry or asymmetry. Myxœdema gives a moon-face; acromegaly, prognathism of the lower jaw with overgrowth of the superciliary ridges. Rickets causes a box-shaped head. A general bulging of the face is seen in neoplasms of the antrum, a unilateral swelling in infective processes of the jaw.

The Neck.—*Enlargement of the lymphatic nodes of the neck* is of great assistance in diagnosis. Bilateral enlargements are found in lues, the nodes being small, hard, shot-like, and movable; in tuberculosis, either of the nodes themselves or secondary to a similar process in the lung; they are usually large, adherent, often fluctuating or soft, and increase progressively in size as one approaches the primary lesion; as, for instance, if due to infection through the tonsil, the largest node lies near the angle of the jaw, while from that point each node decreases in size until the supraclavicular lymphatics may be noted only with difficulty. Bilateral enlargement is seen in Hodgkin's disease, the nodes standing out in great bunches and the enlargement continuing into the axilla.

Unilateral enlargement is secondary to infective processes of the jaw, to faulty dentition, to malignant growth of tonsils, tongue, salivary glands, lips, or to tuberculosis. Occasionally it is seen in carcinoma of the breast and pylorus. The *mouth* should be examined as to the state of the tongue, the presence or absence of malignant disease or chancres; the gingival border, for the blue line of lead- or green line of copper-

poisoning. The state of the *teeth* is of importance, particularly in lymphatic enlargement of the neck, in alveolar abscess, and as a possible source of infection in meningitis and antral abscess. Sordes are seen upon the teeth in low fevers. The *breath* has a sweet odor in pyæmia, a penetrating putrid odor in gangrene of lung, and a characteristic foul smell in epithelioma of the tongue or tonsil. Erysipelas usually starts from the angles of the mouth or eyes or alæ of the nose and spreads therefrom. It rarely crosses the middle line.

Tumors of the thyroid body rise and fall with deglutition. They may be unilateral or bilateral, fusiform or globular, and are common in women: the growth is often coincident with pregnancy, and can readily be distinguished from aneurism of the carotid by the foregoing symptom and by pressure-effects in the latter, and by the fact that aneurisms follow the line of the great vessels.

The *ear* should be examined for the presence or absence of a discharge, whether of pus, denoting middle-ear and possibly mastoid disease, or of blood, which with history of injury points to fracture of the skull, in which case the blood is soon replaced by a serous discharge of cerebro-spinal fluid.

Expansile pulsation is seen often in the suprasternal notch in aneurism of aorta.

Upper Extremity.—The general contour of the *shoulder* should be observed, particularly where there is a history of injury. Too much stress cannot be laid upon the importance of observing not only the injured but also the sound shoulder. Great stress is laid upon this point, which it is necessary to follow not only about the shoulder, but also at the elbow, the wrist, the hip, or the ankle. In other words, compare the injured with the sound part: by doing this not only may the pathological condition be discovered, but also often much time and expense may be saved in court.

One general proposition should be laid down which not only covers the upper extremity, but also the lower, and takes in every joint of the body; and that is, any swelling in or about a joint which follows the general contour of the joint is due to some lesion within it. Whether this lesion be diagnosed as due to blood, pus, or serum depends entirely upon the skill of the observer. And, on the other hand, any fusiform swelling about a joint when the demarcation of the capsule which marks the limit of the normal joint cannot be made out is due either to effusion, which may be purulent, or to malignant growth.

Dropping of the shoulder is seen in fracture of the clavicle; marked prominence of the acromion in subglenoid dislocation. The fusiform swelling which follows the foregoing rule is limited by the capsular ligament in joint diseases, which must be differentiated from the more fusiform and less well-defined swelling due to sarcoma.

Flatness of the shoulder is seen in atrophy of the deltoid muscle, which may be caused by injury or disease of the circumflex nerve, and in fracture of the humerus. If, following injury, a large swelling, filling the axillary fossa, which may or may not have expansile pulsation, appear, with absence of the radial pulse, it would indicate traumatic *aneurism* of the subclavian or axillary artery.

In elderly people pulsation is often observed at the inner side of the elbow, and is due to arterio-venous aneurism of the brachial artery and cephalic veins. It often results from careless bleeding.

The *arm* is swollen and œdematous in infective processes; *e. g.* if the hand be involved in a cellulitis or a malignant œdema. This swelling is accompanied by a brawny feeling and by constitutional symptoms, which are absent when it is secondary to incomplete extirpation of the mammary gland and lymphatic nodes. In this latter condition the marble-like œdema is due to obstruction to the venous return caused by the scar.

The *axillary lymphatics* are enlarged in carcinoma and infective processes in the mammary gland, in inflammation of the hand or arm, in tuberculosis of the lymphatic nodes of neck, in lues, and occasionally in irritation of the female breast. The epitrochlear node is enlarged in infections of the hand and in syphilis. Great importance is put upon its enlargement in the diagnosis of the latter condition.

The Elbow-joint.—When the elbow is extended the inner condyle, olecranon, and external condyle will be on the same transverse line. This is very important, as when there is any dislocation these three bony points will be out of line, while, on the other hand, in a fracture which does not involve the joint they will still remain in their normal position. Inspect the forearm for atrophy of muscle-groups which may be due to injury or disease of their respective nerves. Local enlargements of the bones of the forearm are common: those with a tender, brawny surface are seen in inflammations, either subcutaneous, subperiosteal, or of the osseous tissue itself. Toward the distal extremity, particularly if there be a history of injury, look for the silver-fork deformity of Colles' fracture and for the shorter and more abrupt deformity seen in a backward dislocation of the carpus. Severe infections of the hand are accompanied by brownish-red streaks running up the arm to the lymphatic nodes—*i. e.* lymphangitis—or else by the purple lines of phlebitis.

Much may be learned as regards the general condition of the patient from the *hands*, as the claw-hands of pseudo-muscular atrophy, the general flexion of fingers and hand seen in severe palmar or digital inflammation, the general overgrowth of fingers of acromegaly, the spade-like hand of myxœdema, the clubbed fingers of phthisis, the cyanosis seen under the nails, indicating poor circulation, and hence often observed in conjunction with the clubbed fingers of phthisis, or the small round ulcers or scars occurring on the tips of the fingers observed in Reynaud's disease. A small fusiform, semi-fluctuating swelling in the line of a metacarpal bone or phalanx is diagnostic of spina ventosa. The fingers of gout and of rheumatoid arthritis are excellent indices of the patient's condition. Wasting of the interosseous muscles is seen in progressive muscular atrophy and in leprosy. Athetosis due to intracranial lesions, or glassy skin, with absence of hair, seen after nerve-section, should not escape observation.

The Chest.—Observe the *shape:* in emphysema it is barrel-shaped; in rickets the sternum is pushed forward (the so-called pigeon breast) and is associated with that enlargement of the costal cartilages known as the "rickety rosary." A long, flat, narrow chest indicates a tendency to tuberculosis of the lung.

Unilateral enlargement is found in pleural effusion, whether of pus, blood, or serum. The fifth interspace to the left may bulge, and is the favorite pointing-place for a purulent pleurisy. *Protrusion of the sternum* is a common symptom of aortic aneurism and mediastinal tumors, while in these conditions there is a prominence of the cutaneous veins of the

chest due to deep obstruction. The *scapula* is prominent in lateral curvature of the spine, whether the scoliosis be primary in the vertebral column or secondary to unequal lengths of the legs. In fracture of the clavicle the winged scapula is common, as the fracture itself allows the shoulder to drop forward. The *accessory muscles of respiration* are brought into play when there is obstruction to respiration, whether the obstruction be in the larynx as a foreign body or a membrane, or whether in the lung itself, as in fat-embolism. *Cheyne-Stokes' respiration* is met with in fatty degeneration of the heart, tubercular meningitis, uræmia, and apoplexy. *Unilateral immobilization* is significant of pneumonia, pleurisy, and fractured rib.

The Breast.—Observe the *general contour*, the condition of the *nipple* and its *areola*. It is enlarged in lactation, sarcoma, chondroma, and abscess; its size is decreased after the menopause and in atrophic scirrhus. The presence of cloasma denotes pregnancy or uterine disorders. The nipple is only retracted in carcinoma. Oftentimes the areola may have a bacony, waxy, or lardaceous appearance—Paget's disease—which precedes mammary cancer from one to three years. The breast has a general protuberance in sarcoma and retromammary abscess. Primary syphilitic lesions are not infrequent about the nipple, due to an infected nursing child. Oftentimes from the nipple, in women who have passed the menopause, a thick, purulent-looking fluid can be squeezed: it may be mistaken for pus, but its true nature may be diagnosed by the microscope.

Carcinoma, the most frequent malignant mammary neoplasm, is usually situated to one side of the nipple. The tumor is the size of a walnut, is hard, adherent to surrounding structures, hence not sharply defined, and the overlying skin is coarse and has been likened to pigskin. The nipple may or may not be retracted. The axillary lymph-nodes are enlarged. *Sarcoma* invades the whole breast, which is much increased in size, presents no distinct border, and is of unequal consistence; overlying veins are prominent; there is no axillary involvement unless ulceration has commenced.

In *retromammary abscess* the whole breast is protruded; there are axillary involvement and associated symptoms of inflammation. Occasionally a small hard tumor is found with associated axillary involvement in a middle-aged woman, which may be mistaken for carcinoma. It is a retention-cyst, and may be distinguished by its depth in the gland, its lack of infiltration and of skin-changes.

For the recognition of any tumor of the breast the *palm* of the hand should be used. Any one, if he feels with his fingers, can find a tumor in a normal breast, which is simply mammary-gland tissue. If the palm of the hand be taken, the mammary gland spreads itself out against the ribs, but any tumor by means of this procedure will readily be distinguished. In examining for adhesions the arm should be abducted to make the great pectoral muscle tense; if the muscle is relaxed, false diagnosis is easy.

If an ulcerating breast present for diagnosis, attention should be given to the character of the secretion: blood is common in sarcoma; a thin, sanious watery secretion and occasionally scabs are seen in carcinoma. Small blue circumscribed spots upon the anterior surface of the chest—*taches bleuâtres*—are caused by pediculi either of the pubes or axilla.

Abdomen.—From the general appearance of the abdomen much

may be learned. Rigidity and oftentimes rigid retraction are seen in dyspnœa when the respiratory muscles, particularly those of the belly, are brought into play. Rigidity of the right side, particularly of the rectus muscle, is seen in peritonitis or appendicitis. The manner of observing this should be as follows: With the thumbs of both hands pressure should be made upon each rectus, beginning at the symphysis pubis and following the line of Poupart's ligament. Starting again from the symphysis pubis, both recti muscles should be palpated up to and beyond the umbilicus. In examination of the belly the hand should be warm, as a cold hand will often cause, particularly in women, a momentary contraction of the muscles which may mask any diseased condition beneath. Observe whether the patient or the belly itself shrink at the approach of the examining hand. This is of great diagnostic value, particularly in deep-seated pain. Often the stomach may be partly outlined, particularly in thin subjects, and its size may be noted, as, for instance, in increase due to pyloric obstruction. A sausage-shaped tumor in the right inguinal region, chiefly seen in infants, is due to intussusception of the bowel.

The *general contour* of the belly should be observed. The pouting of the navel in anasarca, the lack of this in ovarian tumors, the ball-shape of ascites, the general distention of the peritoneal cavity observed not only in the foregoing disease, but also in cancer of the peritoneum itself or of the colon or liver, often a symptom of hydatid cyst,—these are all of importance. Marbling of the belly, due to obstruction of the venous flow, is seen in pregnancy, liver diseases, ascites, and tumors pressing on the deep veins.

Enlargement of the spleen, which can be easily distinguished, may be due to malignant disease, to leukæmia, or to malaria. In local enlargements between the costal borders and below the xiphoid cartilage, if hard, cancer of the stomach, usually pyloric, is thought of, but when soft, pulsating, and expansile, they are caused by aneurism. General protuberance of the bowels is often a most characteristic symptom of tumors of the kidney, which push the bowel forward; hence one should not be deceived by tympany on percussion. Tumors of the right hypochondrium, are usually of the liver and gall-bladder; of the left hypochondrium of the spleen or a distended stomach; renal tumors may be found on either side. In the right iliac region tumors may be caused by disease of the cæcum and appendix, by pelvic abscesses, fecal accumulations, or cysts of the ovary and broad ligament; in the left iliac, by tumors and cysts of the ovary, pelvic abscess, or volvulus. In the umbilical region we may find tuberculosis of the mesentery, and tumors may present themselves here which spring from other regions. In the hypogastric region the most common tumors are pregnant uteri, distended bladders, and fibroids. Lumbar tumors spring from the kidneys, or are cysts, perinephritic abscesses, or occasionally perityphlitic abscesses.

When peristaltic motion is observed from without it is often due to obstruction of the bowels. Board-like rigidity with distention is seen in tubercular peritonitis.

One may meet with the pelvic enlargement of ovarian tumors, the general bloating or distention of peritonitis and intestinal obstruction; the doughy, brawny swelling, spreading from the pubis, of extravasated urine; also with scars

along the side, indicating previous pregnancies or the results of great abdominal distention. Occasionally one sees, particularly at the navel, a persistent omphalo-mesenteric duct which may discharge a purulent material or even intestinal contents. A discharge at this point may be from a persistent urachus. In these latter conditions there will be more or less excoriation around the umbilicus.

Observe the middle line particularly for old scars of previous operations, for hernia at the umbilicus, or separated recti muscles, and particularly, in the inguinal region, the condition of the inguinal rings. Pulsating swellings may be observed which if in the longitudinal axis of the body might indicate aortic aneurism, although aneurisms of the superior mesenteric artery are not infrequent. A flask-shaped tumor arising in the middle line from the pelvis, which often may reach the umbilicus or even beyond, and which fluctuates and is elastic, is probably a distended bladder, which may be mistaken for a more serious condition. A tumor in either flank about the size of one's fist, which possibly can be grasped by the hand, with the history of movement, change in position, sharp colicky pain, and a lessened secretion of urine, usually indicates a floating kidney. This is particularly true of the right side. An elastic, flask-shaped tumor of the right hypochondrium may be a dilated gall-bladder or a hydatid cyst. Swellings in the ileo-costal space almost always originate from the kidney or surrounding structures. For instance, a dense, brawny infiltration on one side, with other characteristic indications of pus, would show the presence of perinephritic abscess, in which fluctuation is rarely detected. The diagnosis is made upon its pitting, the induration, and the history. Tumors here with unchanged skin, particularly in the young, almost always spring from the kidney proper, and, if in the very young, of rapid growth, and of large size, with the other associated symptoms, are chiefly due to sarcoma, although cysts are not infrequent.

The spine should be examined for any local enlargement, beginning at the atlas and going down to the coccyx; as to its general contour, whether there be kyphosis, lordosis, or scoliosis; and as to its mobility, as shown by movement. An undue rigidity of the spine is brought out by asking the patient to pick up an object on the floor. The influence of extension in the correction of deformity should be tried in all curvatures, and in lateral curvatures measurements should be made of the legs for inequality. Cold abscesses lie always to one side of the spine and below the affected region.

In the very young certain tumors present themselves, particularly around the sacrum, the lumbar region, and the coccyx, which are placed centrally, which are deeply connected, may or may not fluctuate, are oftentimes transparent and usually congenital; as, for instance, spina bifida and the sacro-coccygeal tumors and dermoids. In many patients at the lower portion of the sacrum a small sinus, one to two millimetres in diameter, is found, with an intermittent discharge of unpleasant odor—called the *pilo-nidal sinus*—which, while congenital, yet often does not begin to be annoying until early manhood.

In the inguinal region many tumors present themselves for diagnosis, and this is a common seat for error.

A *hernial protrusion*, whether direct or indirect, of the inguinal variety always presents itself in this region, and the diagnosis should be easy by its reducibility or the presence of the characteristic impulse on coughing. A hernia may be confused with the shot-like nodes of syphilis, which are always bilateral, and with the large immovable swellings of Hodgkin's disease or, if unilateral, with bubo from infection from the foot or from the urethra, whether the latter be gonorrhœal or chancroidal. The nodes also enlarge in tuberculosis, epithelioma of penis or leg, etc.

THE GENITO-URINARY TRACT.—**Kidney.**—Constant pain in this region may be due to cancer or to tuberculosis; paroxysmal pain, to stone and foreign bodies. A tearing pain is felt in hydronephrosis and

pyelitis; a dragging pain which at times is paroxysmal, attended by nausea, is characteristic of floating kidney. Tumors of the kidney are not affected by respiration. In perinephritis the patient lies on his back turned toward the affected side, with his legs flexed. It simulates, on the right side, appendicitis. Sudden increase in the amount of urine passed, following suppressed urination, is pathognomonic of hydronephrosis.

The penis should be observed for the presence or absence of scars—for discharges, which are very important, particularly when associated with a painful knee-joint. In elderly people, particularly after fifty-five years of age, a muco-purulent discharge is complained of, which they attribute to former disease, commonly seen a short time after defecation and simply due to enlarged prostate. The normal prostatic discharge is squeezed out by the act of defecation. The presence of a pin-point meatus or adherent foreskin in children may give valuable aid in many conditions.

Testicles.—In any abdominal tumor in the male the presence of testicles should be sought for, as a retained testis is very liable to undergo sarcomatous change. The absence of one or both is important, particularly in painful swellings in the groin or about the rings. A nodular tumor of the epididymis in conjunction with a thickened vas is characteristic of tuberculosis. The testicle is uniformly large in sarcoma and luetic affections.

The **scrotum** is always large, pear-shaped, and fluctuates (or if the tunica albuginea be greatly distended an elastic feel may be substituted for the fluctuation) in cases of hydrocele and hæmatocele. A worm-like condition of the left side of the scrotum which subsides in the recumbent posture, and which may be prevented from recurring when the patient is standing by pressure upon the external ring, is due to varicocele. This is only seen on the left side.

Perineum.—The drawers of the patient should be examined in every case when pain is complained of in this region for the presence of pus and blood, which oftentimes are significant, though not noticed by the patient. If present, gonorrhœa, anal fissure, hemorrhoids, fistula in ano, and epithelioma may be the cause. Urinary fistulæ are common in this region following stricture and urinary extravasation. A brawny, painful mass in the ischio-rectal fossa shows abscess. In this condition fluctuation cannot be detected. Hemorrhoidal tags denote past and possibly present hemorrhoids.

The **groin** is the common seat of herniæ, both inguinal and femoral, which are oftentimes difficult to differentiate. It may be said that if the finger be placed upon the spine of the pubis, any hernia which points externally to the finger is femoral—internal to it, inguinal. In fat people the spine of the pubis is found with difficulty, but may be easily reached if the leg be abducted and the finger run along the tendon of the abductor longus where it is inserted into this bony landmark. A large fluctuating swelling which may point above or below Poupart's ligament, externally or internally to the femoral vessels, or between the tuberosity of the ischium and the great trochanter, with a history of long duration, is possibly a cold abscess, and is very suggestive of spinal or hip-joint tuberculosis.

Enlarged, tender lymph-nodes follow infected wounds of the foot, epithelioma and infection of the penis. They may also be enlarged from tuberculosis. With the history of an injury in elderly people when fracture of the femoral neck is suspected, resistance felt in Scarpa's triangle is very important as an aid in diagnosis, particularly when there is flattening of the trochanter on the same side and a puckering above the patella, which latter is due to a shortening of the quadriceps extensor tendon.

THE LOWER EXTREMITY.—The **knee** is flexed and everted in tuberculosis; flexed and fixed in shortening of the hamstrings; slightly flexed in every joint-effusion, as in this position the joint may be distended to a greater degree with less pain. In "joint-mice" and dislocation of the semilunar cartilages the knee is often flexed and locked. In hydrops articuli the joint is much swollen, but its contour is preserved and the lines of the capsular ligament are sharply defined. In all effusions in the knee-joint the patella is said to float, whether the effused fluid be blood, pus, or serum. Sinuses about the joint are commonly due to neighboring tuberculosis. They are small, often multiple, and present the characteristic granulations of this condition. All joints should be examined for muscle-spasm, which is characteristic of tuberculosis.

The Leg.—The anterior surface and shin are favorite seats for the tertiary lesions of lues. Tenderness on percussion and old scars have great diagnostic significance as to a previous active process. Varicosities, chiefly seen in women, are due to venous obstruction, whether just above the knee, pelvic, or thoracic, and follow the course of the internal saphenous vein, and often are associated with an obstinate pigmented ulcer on the shin.

The Foot.—Pain felt in the arch, with no perceptible injury, may be due to flat-foot. Distention of the ankle-joint, whose normal structure will not admit of much fluid, is seen in tuberculosis; tenseness of the tendo Achilles in talipes equino-varus.

THE DIAGNOSTIC SIGNIFICANCE OF PAIN.

The writer is indebted to Dr. J. H. Musser for the following classification and paragraphs on Pain:

Pain is primarily due to either *functional* or *local* causes, the functional being illustrated by the headaches of anæmia or the heel-pain of gout, while local causes may be due to hyperæmia, inflammation, or injury.

Pain is shown (1) by *facial expression;* (2) by *posture.* It is often pathognomonic, as, *e. g.*, the doubling up in cramps; the bent knee of arthritis; the retracted head of meningitis; the straining attitude of dysuria; the support of the arm in clavicular fracture; flexion of the thighs in peritonitis; the ape-like posture with general tremor seen during micturition with vesical calculus; the sudden upright posture in angina pectoris; the support of the head in cervical caries; the eversion of the leg in fracture of the cervix femoris; the rigidity of the injured side in fracture of rib; the immobile side in pleurisy. (3) By *reflex actions*—as, *e. g.*, stiffening of the belly-wall in peritoneal inflammations, especially upon palpation by examining hands; the erections of urethral irritation and frequent urination of bladder disorders; and the brassy

cough of aortic aneurism. (4) By the associated phenomena of disease, injury, etc.

According to Musser, pain should be studied for the following aspects: First, the *mode of onset;* second, *duration;* third, *time of occurrence;* fourth, *character;* fifth, *seat;* sixth, *whether affected by heat, cold, pressure, posture,* or *rest.*

(1) MODE OF ONSET oftentimes gives clue to morbid processes.

Sudden onset points toward inflammations of serous membranes, as in peritonitis; or to obstruction of some normal mucous canal, as in appendicitis, obstructing gall-stones, or vesical calculi; or to rupture of an organ or part, as sudden pain in an aneurism or in perforation of the stomach and intestines: sudden pains are also observed in neuralgias, particularly in the branches of the fifth nerve. Slow pain usually betokens slow development, as, for instance, painful urination due to enlarged prostate.

(2) DURATION shows the acuteness or chronicity of the cause.

Pain of long duration is always associated with a long-standing cause. It should be noted whether it is temporary or constant, as from this one may be able to judge of the disease: temporary pain may indicate either relief or a cessation of the disease, while constant pain points to a constant cause. As an example a temporary pain is felt in the passage of hard fæces, yet constant pain during the passage points to some organic lesion of the rectum, as fissure or hemorrhoids. The duration may indicate the prognosis, as when in a strangulated hernia the pain ceases gangrene may have occurred. Pain following shock shows that reaction has set in, and hence is a favorable sign. "The abdominal surgeon should welcome its presence after operation" (Musser).

Constant pain is seen particularly in organic lesions, in inflammations of all the tissues, particularly those of bone. It may be reflex in character, as the pain and uneasiness felt in the right shoulder which is more or less constant from gall-stones. *Paroxysmal pain* is usually associated with nerve-lesions or neuralgias, and also with obstruction to some canal by a foreign body. *Periodical pains* are chiefly due to malaria or syphilis or to some atmospheric influence, or are in relation to some physiological process.

THE TIME OF OCCURRENCE OF PAIN.—Nocturnal pains are common in lues, in all inflammations of bones, as seen in the night-cries of children with hip-joint disease.

Pains in the day are oftentimes due to the position of the patient, such as pain in the instep due to flat-foot. The time and the relation to some function are often very important. Gastric pain coming on before meals means gastralgia; that occurring after meals is due to some organic lesion of the stomach, as cancer or ulcer, or at times to dyspepsia. A common example is the pain in cystitis which is felt before urination, and which is relieved by this act. This pain is due to the contact of the urine with the irritated and sensitive mucous membrane. Pain occurring during micturition points toward stone or inflammation of the urethra; pain occurring after it often is due to stone, when the bladder contracts upon its rough surfaces. This pain is usually relieved as the urine accumulates and lifts the bladder-wall away from the calculus.

THE CHARACTER OF PAIN.—Pain may be spoken of as being due to *soreness, tenderness, aching, lancinating,* or *throbbing,* and from each of these characteristics one is able to learn much of its cause.

Soreness, particularly on movement, often indicates muscular or ligamentous origin. An aching pain is due to nerves or muscles. Aching pains may be general, and often usher in more serious general constitutional diseases, as the general pains in the bones preceding influenza. Throbbing pain is often an accompani-

ment of acute inflammation, which, if it has been of several days' duration, points many times toward abscess-formation. Sharp and lancinating pain is seen in obstruction to canals by some foreign bodies, particularly calculus, and also in inflammation of serous membranes. A dull pain, particularly in bones, betokens a chronic, slow inflammation. Pain accompanied with tenesmus is usually associated with foreign bodies, as blood and stone, and is noted chiefly in the rectum and the bladder.

The character of the pain often indicates the structure involved—as, *e. g.*, itching, burning pain in skin and mucous membranes, while the soreness which is increased on movement and pressure is characteristic of muscles. A deep-seated, boring pain is characteristic of bone-lesions. A sharp, lancinating pain points toward nerves. A dull, constant, aching pain is often associated with disease of some viscera. If the lightest contact to any part elicit pains, it points toward affections of the cutaneous nerves. If the skin can be freely handled without causing pain, this source can be eliminated. If deeper pressure on the groups of muscles be made and soreness be complained of, it points toward muscles. If, on making deep palpation over the location of a bone deep-seated pain is elicited, while the skin and muscles are free from pain, bone-lesions, chiefly of inflammatory nature, may be thought of.

THE LOCATION OF PAIN may be said to point fairly accurately to the lesion, providing that the nerve-distribution is recalled; but one should always remember the possibility of referred pain. Examples of this are very common and frequently overlooked, hence the disease is not treated. Mention is made here of some of the commonly referred pains which are apt to mislead.

Pain over the right shoulder is associated with gall-stones by means of the vagus and the third or fourth cervical nerves. Pain back of the ear may be due to mastoid disease, particularly if there be tenderness over this region; but the mouth should always be examined for carcinoma of the tongue. Knee-pains often mean hip-joint disease. Pain in angina pectoris radiates down both arms. In renal disease it follows Poupart's ligament or is felt in the bladder or the testis, or may radiate down the inner surface of the thighs. In vesical calculus pain is felt at the end of the penis. In diaphragmatic pleurisy it is located above the umbilicus and to the front. In Pott's disease anywhere in the spine it is always referred to the anterior surface of the body. The high cervical Pott's lesion will give pain in the throat, with irritation which is too commonly treated for a cold. In disease at the junction of the cervical and dorsal vertebræ pain is referred to the intercostal nerves and their distribution, and is often called "intercostal neuralgia:" mid-dorsal pain is referred about the belly, and in small children is frequently thought to be due to colic. In disease of the lumbar spine pain is referred down to the pelvis.

Pain between the shoulders oftentimes is due to aneurism or to cancer of the œsophagus; pain in the neck may be transmitted by the phrenic nerve and be due to pericarditis or diaphragmatic pleurisy. So-called sciatica is often caused by a fissure of the anus, by cancer of the rectum, or by ulcer, and may be cured by treating these conditions. The pain of hip-joint disease may not only be felt in the knee, but may extend to the heel. Never make a diagnosis of "rheumatic" and "growing pains" in a child without a thorough examination, looking particularly for tubercular disease in some joint or joints.

PAIN MODIFIED BY PRESSURE AND MOVEMENT—Pain increased by pressure is due to inflammation; if relieved it is either neurotic or functional. Pain that is relieved by pressure, particularly around the belly, often is due to a reposition of some organ which has been dislocated: this is chiefly seen in the kidney, as when a patient himself can replace a movable kidney and thus relieve the characteristic sickening pain of this affection.

Pain that is increased by pressure at "nerve-points" means neuralgia. If by pressing upon the head or by having the patient jar himself by his feet pain be

elicited along the spine, it is characteristic of Pott's disease. The influence of movement is very suggestive. The contraction of an inflamed muscle is painful. If it be found that certain active movements are painful, but that the movement can be made passively without causing pain, it may be put down as muscular. It is not the position of the limb which is painful, but the method of obtaining it. Ligamentous pain, whether active or passive, is elicited by any movement which stretches the ligament; hence in moving any joint, if it can be done passively to its normal degree without causing pain, the articular surface composing that joint may be said to be free from disease; but the moment the joint and the ligaments about it are put upon the stretch and pain be elicited, it is ligamentous in origin.

Pain in Special Regions.—Pain in the extremities, if bilateral, may may be due to disease of the spinal cord or to neuritis, toxæmia, or pressure; if unilateral, to injury, inflammation, or pressure, or to transmitted sensations.

Pain in the foot is usually caused by flat-foot; in the heel, by gouty or rheumatic conditions, although it may be caused by aneurism of the popliteal artery pressing on the popliteal nerve. Pain in the space between the third and fourth metatarsal bones is due to pressure on a small branch of the plantar nerve, which is nipped between the articular ends of the two contiguous bones. Pain is usually located in the shoulder when due to liver disease; in the back, when due to disorders of the stomach; in the interscapular region, in ulcer of the stomach. Pain behind the sternum, common in gastric disorder, may also be due to aneurism, tumor, or angina pectoris. Pain in the sternum or ribs may be due to syphilis or periostitis. The pain in the loins, when acute, may be due to a dislocation of the kidney, to calculus, to uterine disorders; when chronic, to uterine and renal disorders and varicocele.

Cough.—In aneurism of the carotid, and even of the aortic arch, a peculiar metallic, brassy cough and irritation of the throat are complained of. The dry, constant, hacking cough due to irritation, which by turn is caused by pressure, is often seen in women with thyroidal enlargements and in many tumors of the neck. The constant cough of irritation due to enlarged uvula, and a cough similar to that described above as due to pressure of tumors, may be found associated with carcinoma of the œsophagus. Cough may be also caused by the presence of a foreign body in the auditory meatus. It is transmitted along the auriculo-temporal branch of the fifth nerve. In infants cough may be due to irritation of the stump of a tooth.

CHAPTER XXI.

THE METHODICAL REPORT OF A SURGICAL CASE.

By Edmond Souchon, M. D.

The methodical report of a surgical case comprises the history of the patient, present condition, diagnosis, course and treatment, termination and sequels, and, lastly, in case of death, the post-mortem examination.

History of the Patient.—*First.* Note the sex and age of the patient.

Second. Note the race and nationality.

Third. Note the family history—*i. e.* the age and the condition of health of the parents, if living; if any parent be in bad health, ascertain the name and nature of the disease and its course and duration, if possible; if dead, the age at which death occurred and the cause of death. This applies to the ascendants (father, mother, grandfather, grandmother, both on the paternal and the maternal sides), to the collaterals (uncles, aunts, cousins), to the descendants (children, grandchildren). Note the parent the patient resembles the most or takes after physically.

Fourth. Note the place of birth; also the various places where the patient has lived; the duration of his stay in each place.

Fifth. Note the effects, if any, of the various causes as ascribed above, including the cause to which the patient attributes his disease.

Sixth. Note the condition of health previous to the attack; also the date and mode of début, the premonitory and prodromic symptoms (subjective, physical, functional, regional, and general). Note the order of succession of the symptoms, the duration of this period, the treatment undergone, and the effect; the course of the disease up to the date of the present record.

Present State.—The description of the present state includes the mention of all the symptoms presented actually by the patient—subjective, physical, functional, regional, general.

Diagnosis.—The diagnosis is now made in the following manner:

First. Make a résumé of the salient points or signs of the case derived from all sources—sex, age, race, nationality, place of birth, places where he has lived, effects of the various possible causes of the disease, course of the disease.

Second. Note the diseases resembling the case.

Third. Differentiate them.

Fourth. Diagnose the stage and give the probable termination.

Fifth. Diagnose the forms or varieties, the complications.

Course and Treatment.—The course and treatment call for a record of the day and hour when any changes of consequence take place in the symptoms (subjective, physical, functional, regional, general) or in the treatment (hygienic, medical, surgical, etc.). Note relapses (date, causes, symptoms, etc.); also recurrences.

Termination of the Disease.—The termination of the disease should be well noted; the sequels or consequences, if any, should be carefully mentioned.

Post-mortem Examination.—The post-mortem examination should be conducted after the rules laid down in the best works; that is, the lesions of the main organ should be described first, then those of the region, then of the distant or general organs; the microscopic lesions should be also noted.

Final Record.—The final record must be complete: it must include all the above; also the various charts (temperature, pulse, respiration, stethoscopic, plessimetric, sphygmographic); photographs, drawings, sketches, microscopic slides, if any, should accompany the record; the pathological specimen should be deposited in a museum with a distinct number for reference; the label should explain the main features of the case.

Rules to be Observed by the Recording Surgeon.—(1) Put the questions with politeness and solicitude; kindness and gentleness will accomplish more than any other policy. (2) The phenomena should guide one toward the solution sought; do not shape the phenomena toward a desired solution. (3) The number of questions must not be too numerous nor be too few. (4) Use plain, simple words and expressions which the patient will understand. (5) Do not propound complex questions which bear on several points at the same time. (6) Put the questions in such a manner that the answers should be simply *yes* or *no*. (7) Do not allow the patient to indulge in too minute details; however, patients must be allowed a free statement: when they digress too much from the main point bring them back to it, but gently and with care, otherwise they may become scared or nervous or sullen; some resent it by wilfully giving false answers. (8) When the surgeon doubts the veracity of the patient, or when the answers lead to an extraordinary fact, the surgeon should change the terms and forms of the questions: he should cross-examine; he should return to this same point later in the examination; sometimes it is better to return to it the next or some other day: should the patient then give different answers on that same point, he should be reminded of his former answer; the version he finally adopts is usually the true one, or the fraud, if any, is more easily detected. (9) Put as few questions as possible in cases where quiet or silence is necessary (great pain, shock, etc.). (10) Proceed with gentleness in the physical examination, especially of the organs of generation and of the anus, particularly in the female. (11) Do not expose the patient any more than absolutely necessary, not only on account of modesty, but because exposure may cause cold. (12) Questions relative to syphilis must be put with care—never in the presence of the wife, or conversely, or of parties objectionable to the patient. (13) Avoid questions, words, movements, or facial expressions which might convey an unfavorable impression to the patient. (14) Take into consideration the social position and the character of patients in examining them, as some are more nervous and sensitive than others.

Methods of Interrogation.—There are two methods of interrogating a patient:

The *first method* consists in beginning to review all the possible features of the case, following closely the order above described. This procedure is long and tedious, because the local trouble is only discovered when the turn of the organ comes in the examination, but in obscure cases it is the safest and most preferable.

The *second method* consists in well determining the début, and letting the patient narrate what he feels and knows, so that he will himself guide the surgeon to the affected organ, which will then be thoroughly examined, and afterward the organs at large.

Methods of Diagnosis.—The *method by hypothesis* consists in taking up at once the disease which the symptoms suggest to the mind, and seeing if all the important signs fit it or not: if they do not correspond, then the next disease which suggests itself is considered, and so on until a disease is found that corresponds to all or most all the important signs.

The *method by exclusion* consists in precising the salient signs of the history; in noting the diseases to which those signs may belong, thus eliminating at once all diseases where those signs are not usually observed; in determining the diseases to which the signs do not correspond thoroughly, and eliminating them, one after the other, according as signs correspond less and less, so that in the end the only disease retained is the one to which the signs correspond best.

Remarks—*First.* In cases where the data are insufficient all the regions and organs of the body must be examined, one after the other, before the diagnosis can be reached, as in cases of general injury with no special localization; or where the patient is incapable of precising in any way or gives contradictory or vague, worthless answers with a view either to deceive the surgeon, or because of a lack of intelligence, or because of the absence of any predominating sensations; or when there is unconsciousness, delirium, intoxication, or coma. The diagnosis is reached only by the general result of such signs as have been gathered in this way. *Second.* The diagnosis of a disease may be difficult or impossible, at the outset or during all its course down to the termination, favorable or unfavorable, or, when the surgeon is called at the time of impending death, or when the patient simulates a disease or dissimulates the disease with which he is really affected. *Third.* In cases of disease presenting attacks or exacerbations it is important to see the patient at the time of the paroxysm.

PART IV.

INJURY AND REPAIR.

CHAPTER XXII.

WOUNDS.

By Chas. B. Nancrede, M. D.

Subcutaneous Injuries, Contusions, Lacerations, etc.

Subcutaneous Injuries, Contusions, and Lacerations vary in severity from the pain and swelling of the skin, which promptly appear and as promptly disappear, for example, after a cut from a whip—*i. e.* a *wheal*—to complete disorganization of a limb, the skin alone remaining intact. The most common causes are blows from or falls upon blunt objects, the passage of wagon- or car-wheels, and entanglement of a limb in ropes or machine belting. The connective tissue with its vessels always suffers. When only a few vessels are ruptured an *ecchymosis* or *bruise* results, with pain, tenderness, swelling, and discoloration of the parts, the effused blood as it reaches the surface *changing its purplish hue* to a brownish, green, and yellow tint as it fades away. The effusion may either be evenly distributed throughout the damaged tissues—*hemorrhagic infiltration*—or form circumscribed collections—*ecchymoses or sugillations*. In lax tissues, as the axilla, or where a limb has been traversed by a wagon-wheel, the major part of the skin may be stripped off from the deep fascia, and the cellular tissue and the intermuscular spaces be distended by such an enormous extravasation that death results from the sudden abstraction of blood from the circulation, or gangrene occurs because the pressure upon the small vessels is such that the collateral circulation cannot be set up. These accidents rarely occur except as a result of the giving way of a large vein—*e. g.* the axillary or external iliac. When the larger blood-collections become circumscribed by condensation of the surrounding tissues, they are called *hæmatomata*. Occurring in certain regions, a prefix or suffix is added to indicate the locality—*cephal* when occupying the scalp (*cephalhæmatomata*); *arthrosis* when a joint is concerned (*hæmarthrosis*). The pressure exerted by the effused blood usually arrests the bleeding, and *coagulation* generally sooner or later occurs. The *clot* eventually *breaks down* into a thick, reddish fluid which often assumes a brighter tint when exposed to the air. Repair takes place without true inflammation unless infection occurs. The coloring matters of the disintegrated clot diffuse into the surrounding tissues, and with the liquid portions are removed by the lymphatics.

Some of the peripheral leucocytes wander into the lymphatics, but the more central ones disintegrate and are absorbed. These processes sometimes fail or are incomplete; the surrounding tissue-cells, proliferating, circumscribe the effusion by a layer of granulations which develop into fibrous tissue, or sometimes into bone when related to bone. The broken-down contents, decolorized and included in the adventitious sac of fibrous tissue, now form a *cyst*, which may persist, or, after the liquid has been absorbed, leave only a subcutaneous scar, which in turn often gradually disappears. If the vitality of the tissues be seriously lowered by this injury or by previous ill-health, especially if the effusion be large, *suppuration* may occur. The germs gain access locally by (1) some abrasion of the epithelium over or near the injury; (2) the germs normally resident in the skin originate the trouble; or (3) those accidentally implanted. When the pressure of the effusion interferes with the vitality of the skin, already partially deprived of its blood-supply by stripping from the deeper tissues, *blebs* form, through which the infection may occur. More rarely still the germs, gaining access to the circulation at some distant point, reach the injured tissues, where a slowed blood-current favors their accumulation and the impaired vitality of the tissues cannot inhibit or destroy them. Suppuration complicating subcutaneous injuries is common in certain localities as the *thoracic* and *abdominal walls*, while it is said never to occur in cephalhæmatomata in infants. The varying conditions caused by complications, such as injuries of great vessels, nerves, lymphatics, bones, or joints, will be considered elsewhere.

Symptoms.—*Pain*, except when a nerve-trunk is damaged, is dependent upon and proportioned to the tension resulting from the swelling, which varies with the amount of effusion and the laxity of the tissues: when confined beneath tense, unyielding structures, as fasciæ, a small effusion may be productive of severe pain, while a large one in lax tissues, as the scrotum or eyelids, may cause nothing beyond slight discomfort. *Discoloration* shows promptly if the bruise is superficial, but may not appear for many days if the deeper parts are those injured or the effusion occurs beneath an unruptured fascia. At first of dark purple, the color changes to green, then to yellow, finally fading out. *Constitutional reaction*—"aseptic fever," so called—is proportioned to the extravasation and laceration; *i. e.* the amount of fibrin-ferment and nucleins available for absorption. When the injury is superficial the overlying skin presents the evidences of *plastic exudation*—viz. normal reparative processes—which soon disappears unless infection occurs.

Treatment.—*Rest* must be secured for the part by splints, position, or both. Even where no appreciable lesion of the epithelium is discernible, it is better to carefully *sterilize the surface* and employ subsequently only aseptic applications, because portions of the skin may have been actually killed, and yet no evidence of this appear until later: these precautions are imperative if abrasions do exist, lest infection occur. *Cold* may be employed to check effusion by applying ice-bags, iced lotions, or aseptic lotions so disposed as to permit constant evaporation taking place, especially for the more superficial injuries. Alcohol-and-water is one of the best evaporating lotions, to which morphia may be added if desired. The value of lead-water is doubtful. *Irrigation* with cold sterilized water may sometimes prove useful in certain severe contusions, but all cases where any form of cold is used must be carefully watched lest gangrene be precipitated. *Massage* has been recommended for slight contusions, because it favors rapid disappearance of the effused blood by distributing it over a greater area, but a judicious selection of cases must be made, lest more harm than good result. In the more severe injuries the effusion may be checked and absorption

hastened by gentle, *elastic pressure*, such as can be secured by the careful application of bandages over many layers of cotton, first having aseptically emptied all blebs and protected them by proper dressings. If the tension comprises the integrity of the parts, aseptic *aspiration*, followed by gentle pressure to prevent fresh hemorrhage, usually suffices, although incision may be requisite to satisfactorily evacuate large collections if much clot be present. When coldness and œdema of the part show that the collateral circulation is seriously interfered with by the pressure of the effused blood, as this probably comes from a large vessel or vessels, aseptic *incision*, ligature, perhaps packing and proper drainage are indicated.

INJURIES OF VESSELS.

Arteries.—Mere contusion, if the vessel be superficial, compression against a bone if deeper, or overstretching during the production or reduction of dislocations, may cause partial or complete rupture of an artery. In the former variety the internal or middle and internal coats yield, usually in such a manner that, curling upward and downward because of their normal elasticity, they partially or completely occlude the vessel, thrombosis soon rendering complete any partial blocking. Even when the incurved coats do not seriously interfere with the blood-current thrombosis often results.

Precedent *atheroma*, calcification, or softening from inflammatory changes predispose to these accidents. As a rule, occlusive *thrombosis* follows partial rupture of the inner coats of an artery, but sometimes a small, newly-formed, tortuous vessel may extend through the connective-tissue cord which represents the obliterated segment of vessel. When the thrombus gradually forms, with normal collateral vessels and a strong heart-action, the vitality of the distal parts is readily maintained, but with rigid collateral vessels and a feeble heart *gangrene* usually follows. When a limited rupture of the inner coats of an artery occurs, not affording the proper mechanical or vital conditions productive of obliterative thrombosis, reparative processes are set up which render the already weakened vessel more distensible. The remaining coat with the environing portion of the softened vessel either yields gradually to the intravascular pressure, forming a *traumatic aneurism*, or a few days or weeks later the rupture suddenly becomes complete, the blood escaping into the tissues.

SYMPTOMS.—Unless the incurved coats at once block the vessel, no symptoms appear until thrombosis diminishes or cuts off the blood-supply, when the pulse in the distal segment of the artery either becomes feeble or is arrested, according to the rapidity of clot-formation: the part becomes numb, powerless, pale, and cold, with neither swelling nor extravasation to explain the condition. Sometimes severe pain is complained of. Later, if gangrene does not occur, enlarged collateral vessels may be detected. When the rupture involves all the coats and the opening is large, if the surrounding tissues are lax, an enormous soft, fluctuating, imperfectly circumscribed swelling forms in a few moments, and the loss of blood from the circulation may be so great as to produce syncope. The distal portion of the limb becomes swollen, pale, and œdematous, and no pulsation can be detected in the vessels below the injury. Extreme *pain* is common. *Pulsation is absent* in the swelling or can only be detected over a small area: it is not expansile, nor is there usually bruit nor thrill. If a bruit be present, it is not conducted along the vessel. If the surrounding tissues are dense

enough to resist the effusion, a small rent in even a large vessel may give rise, for a time only, to more or less vague symptoms of traumatic aneurism, and then, after some days, perhaps quite suddenly, the barrier yields and the blood spreads widely through the limb, forming a characteristic *arterial hæmatoma*.

Diagnosis.—When immediately after injury a diffuse, fluctuating swelling, perhaps pulsating over a small area, with bruit and thrill, appears in the course of an artery, with cessation of the pulse below, the diagnosis is clear enough; but when the vessel is deep-seated and much inflammation exists, the condition closely simulates acute phlegmon or even a rapidly-growing sarcoma. If neither thrill, bruit, pulsation, nor alteration in the distal pulse can be detected, exploration with a grooved needle or aspirator must precede any active interference in doubtful cases. Traumatic aneurism, arising from yielding of the partially ruptured arterial wall, appears some time after injury and presents the ordinary symptoms of aneurism.

Treatment.—When that surgical rarity, simple occlusion, results from contusion of a large vessel, carefully sterilize the skin, dress with abundance of sterilized cotton, place the limb in an elevated position, and wait to see if gangrene ensue. The gangrene, if it occur, may prove to be less extensive than at first appeared probable, one or more toes perishing instead of the extremity, so that before operating it is better, if possible, under aseptic dressings, to allow the line of demarcation to form and not amputate at the level of arterial occlusion. *Traumatic aneurism* must be treated as indicated by the locality and calibre of the vessel. When possessing a well-formed sac, compression or Hunterian ligation may succeed, as in rupture of the anterior tibial complicating fracture of the bones of the leg: in this particular case spontaneous cure often takes place by the time the fragments are consolidated. As the vessel is healthy close to the point of injury, there is no objection in appropriate cases, when the circulation can be effectually controlled, to cut down and tie the artery above and below the wound, and also any collateral branch opening into the portion included between the ligatures. An arterial hæmatoma—*i. e.* a *diffused traumatic aneurism*—requires prompt intervention. As the condition is really a wounded artery, it should be treated as such if the vessel be of any size. In addition to the danger from mere loss of blood, the effusion often interferes so seriously with the collateral circulation that gangrene will occur unless the pressure be relieved. Gentle compression has been recommended when the extravasation tends to cease spreading and the collateral circulation is fair. This is questionable practice, except for the smaller arteries. When the diagnosis is clear, ligation should be done as directed for traumatic (circumscribed) aneurism. The efficiency of modern methods for controlling hemorrhage, the immunity conferred by asepsis against secondary hemorrhage and septic inflammation, and the certainty of remedying the effects of the injury, all indicate that this is the proper course to pursue. Moreover, the necessary incisions will permit of the removal of so much of the effused blood as will materially relieve the collateral circulation. While amputation at the level of the rupture is the only resource if gangrene of the segment of the limb actually occur, either before or after ligation, the emphatic warning must be repeated

that with aseptic methods the surgeon can usually safely wait until no doubt exists as to the extent of the destructive process.

Veins.—Contusion occasionally produces *rupture* of the internal coats, initiating a *thrombosis* which blocks the vein, but even when the main vein of a limb is concerned the free anastomosis prevents gangrene. The extent of extravasation in subcutaneous rupture of veins is rarely serious in itself, but if one of the main veins be ruptured or a branch be torn off close to the parent trunk, where the surrounding tissues are lax, as in the axilla, the amount withdrawn from the general circulation may threaten life or cause gangrene by interfering both with the direct and collateral circulation.

Treatment.—Elevation of the part, coupled with cold and equable pressure, usually suffices, but where the effusion causes so much compression as to threaten gangrene incision and suture with catgut for small wounds and ligation for transverse wounds should be done, after turning out all the clots. While pressure combined with elevation is often sufficient, suture or ligation is perfectly safe, and more reliable when the effusion tends to spread.

Suture is preferred by many because, although thrombosis sometimes occurs, the vessel usually remains patent. Suture is only possible when the bleeding is thoroughly controlled during the whole procedure; hence it is usually better to ligate.

Lymphatics.—In all contusions lymph is extravasated, and in some cases much of the effusion is composed of lymph. It may even form a fluctuating tumor containing yellowish or reddish fluid. These lymph-effusions most often result from laceration of the lymphatics traversing the subcutaneous cellular tissues, and are therefore most apt to occur when the skin is extensively displaced from the subjacent parts. These tumors form rapidly at the outset, to soon become stationary (*lymph-cysts*). When they progressively increase, rupture with the formation of a *lymph-fistula* may result.

Diagnosis.—This must depend upon the history of sudden appearance after traumatism and the exclusion of a hæmatoma or abscess by the appearances and the exploring needle.

Treatment.—Compression should be tried. If this fail, the tumor should be laid open, any lymph-vessel which can be detected should be tied, and the interior of the cyst be cauterized with diluted carbolic acid: firm packing with iodoform gauze should be continued for some time.

Injuries of Nerves.

Experiment shows that slight blows inflicted upon nerves produce extravasations of blood into the neurilemma and between the nerve-fibres. The fibres are contracted at the point struck and irregularly enlarged above and below. In the more severe cases the Wallerian degeneration sets in within a few days, but where the hemorrhage is very slight and only a few fibres are torn, the paralysis rapidly disappearing, most of the fibres undergo, according to Mitchell, only a mechanical disturbance, and a *restitutio ad integram* rapidly occurs.

Symptoms.—These vary with the severity of the injury. In the

slighter cases *pain* will be felt at the point of injury, immediately followed by *numbness* and *formication* in the peripheral distribution of the nerve. A sensation of burning or heat is often experienced, and even actual flushing of the skin has been occasionally observed. All these sensations usually disappear in a few minutes, but the tingling may persist for several days. In more severe cases the *paræsthesia* and *paresis* continue, neuralgic pain appears, and a distinct *chronic neuritis*, tending to spread and resulting in various trophic lesions, occurs. After the most severe contusions immediate and complete paralysis of both motion and sensation ensues. This may pass away with great rapidity: improvement may not set in for weeks or months, or the paralysis may be permanent.

It is well to note that the peripheral areas supplied by nerves may vary in different individuals, and that anastomoses occur with other nerves: ignorance of these facts has led, and again may lead, to the most erroneous conclusions. Complete rupture of a nerve is of course accompanied by initial pain and immediate sensory and motor paralysis in the area supplied by the severed nerve, the changes consequent upon nerve-section following later.

Prognosis.—This is uncertain in the more severe cases, but neither patient nor surgeon need despair because many months elapse without evidence of improvement. If at the end of one to two weeks the faradic excitability of the muscles supplied by the damaged nerve persists, its continuity is not completely interrupted and rapid and complete recovery may be expected. In most cases faradic excitability rapidly disappears, when the prognosis then becomes difficult. If some muscle or muscles supplied by the damaged nerve are not paralyzed, the nerve is not wholly crushed and recovery is to be expected. If, however, rapid muscular atrophy occur and the reaction of degeneration is present, complete solution of continuity of the nerve-fibres has taken place, although the nerve may not have been actually severed. Restoration of function under these circumstances is very doubtful, and, if it does occur, will require months or years. Usually, even in the worst cases, a gradual improvement is discernible, but one which stops far short of recovery. Again, an ascending neuritis may supervene, when the prognosis will depend upon its course as well as upon the original injury.

Treatment.—When seen early an attempt should be made to limit the effusion of blood and the exudates of repair by perfect rest of the part: morphia is often demanded for the pain. Later, counter-irritation, blistering, massage, and galvanism are indicated. When a well-grounded suspicion exists that the nerve has been actually severed, and no improvement in the paralysis takes place in from eight to ten months—symptoms of neuritis being absent—an exploratory operation may be done, the nerve examined, and if found severed the ends must be freshened and sutured together: if markedly reduced in size at the point of injury, in extreme cases, resection of the damaged portion and suture is indicated. If, despite of appropriate treatment addressed to the neuritis[1] when this occurs, the disease continues to extend, Bowlby suggests that the nerve should be exposed and stretched to free it from adhesions to and pressure by the surrounding inflamed tissues: nutritional changes

[1] See Chapter II. Vol. II., and consult neurological treatises.

are also set up in the thickened nerve, tending to remove the compressing inflammatory exudate.

Injuries of Muscles.

Much pain, effusion of blood, and loss of power may result from contusion of muscles, but these symptoms are usually only temporary. Sometimes permanent *atrophy* follows. This may perhaps be due to serious interference with or deprivation of arterial blood by the pressure of the hemorrhagic effusion producing an *ischæmic paralysis*, but more probably results from myositis, causing coagulation-necrosis, fatty degeneration, and destruction of the muscular fibres. External violence may rupture the sheath or a part or the whole of a muscle, or sever both muscle and sheath.

Symptoms.—As just stated, contusion—*i. e.* more or less extensive laceration of a muscle—produces pain and loss of function lasting for a variable period, but complete division presents additional symptoms. Sudden, sharp pain is felt, followed by a dull aching and loss of power. The ends freely retract, and the interval can be felt to increase if attempts are made to contract the muscle. Much blood is effused between the ends of the muscle and into the surrounding tissues. In due time this is absorbed, and repair is effected by the formation of *cicatricial tissue*, unless the ends are too much separated, when atrophy usually results with loss of function. If but little separation has taken place, partial regeneration of the muscle-elements may occur, so that the scar is not wholly fibrous. Much of the original power is regained by the muscle, especially if only a small gap has to be filled by scar-tissue, but permanent atrophy or contracture may result.

Treatment.—Mere contusion must be treated by placing the part in such a position as will relax the muscle, and this must be maintained by splints aud posture until healing occurs. If *ruptured*, two courses are open to the surgeon: The injury can be treated as just recommended for contusions, in addition maintaining quiet of the muscle by firm bandaging, which should be so applied as to approximate the separated ends and restrain further effusion of blood. Cold may also prove serviceable. When the restoration of the function of the injured muscle is of great importance, antiseptic *incision* and *suturing* should be done, care being exercised in passing the sutures to include, when possible, in some of the stitches the aponeurotic covering of the muscle, as otherwise the sutures too often cut out before union takes place. Even with considerable separation and a large scar the functional result is so often good that operation is seldom indicated. Electricity, massage, active and passive exercise will aid in restoring function. Secondary suturing where a large gap exists and the case is of some standing will usually fail.

Hernia of a muscle, when following distinct traumatism, results from an unhealed rupture of a portion of the investing muscular aponeurosis.

Symptoms and Diagnosis.—During the contraction of the muscle an elastic, almost fluctuating, mushroom-shaped protrusion occurs, which disappears as soon as the muscle relaxes.

Treatment.—This may be palliative or curative. The former is carried out by a pad attached to an elastic belt or garter. If productive of serious inconvenience, aseptic *incision*, freshening of the margins of the fascial rent, and *suturing* should be done: as a precautionary measure a pad and elastic girdle should be worn for a time.

Tendons seldom suffer from contusions, but repeated injuries and strains sometimes lead to ossification, as in so-called *rider's bone.* Ruptures, especially of the quadriceps femoris tendon, sometimes occur from glancing blows, as by the end of a wagon-tongue.

Symptoms.—They are similar to those of division of a muscle—viz. pain, sudden loss of power, a gap between the extremities of the tendon, and effusion of blood.

Treatment.—This should be by suture if the tendon belong to an important muscle and the separation be great. If this cannot be done or is deemed inadvisable, the same treatment as was recommended for a ruptured muscle must be adopted, remembering that diminution, not complete loss of power, is the worst that will follow the lengthening of the tendon. Secondary suture may be tried if palliative treatment gives a poor functional result.

Contusion of Bone.

The blood may be poured out beneath the periosteum or into the cancellous tissue, in the former position being usually only small in amount, except in *children*, in whom the periosteum is much more vascular and less firmly adherent to the bone than in adults. This is especially true of *cephalhæmatomata*, where quite large accumulations form, which by subsequent changes closely simulate a depressed fracture because of partial ossification of the margin of the exudate. Absorption of the effused blood, after the manner already described, is the rule here as elsewhere, and suppuration is rare.

Sometimes the effused blood becomes permeated with numerous plasma-cells and organization results in bone-formation; this termination occurs most frequently in syphilitics and rheumatics. Where osseous tissue itself is concerned in the injury, the hæmostatic thrombi may involve the afferent or efferent vessels of a given area, when, unless a collateral supply exists, *quiet necrosis* will result. Two terminations are here possible: either the dead bone, acting as a persistent irritant, causes a more or less extensive osseous thickening and sclerosis, or, pyogenic organisms reaching the damaged area, acute or chronic suppurative osteitis or osteomyelitis will result.

The symptoms and treatment of these several results are considered in the chapter on Diseases of the Osseous System.

CHAPTER XXIII.

GUNSHOT WOUNDS.

By Charles B. Nancrede.

In civil life small shot, pistol-balls, and, more rarely, rifle-bullets are the vulnerating bodies, but in military practice injuries inflicted by fragments of shell, cannon-balls, grape and canister shot, or splinters of wood or stone set in motion by large shot, are included under *gunshot wounds*. Injuries produced by flying pieces of caps and exploded gun-barrels are also spoken of as gunshot wounds.

Missiles.—Shot ranges in size from *dust*, each pellet weighing $\frac{1}{20}$ of a grain, to *buckshot*, weighing 153 grains. *Pistol-balls* are of a calibre from .22 to .45 inch, and weigh from 25 to 250 grains. All modern missiles approach a conical form. They may be pure lead (compressed into shape, not cast) or be hardened by the addition of from 2.5 to 5 per cent. of tin. In addition, military projectiles are covered by a thin covering (*jacket or mantle*) of steel, nickel, copper, or alloys of copper and nickel, or copper, nickel, and zinc (Maillechort).

Formerly of a calibre of .50 to .71 inch and weighing from 400 to 760 grains, the most recent missiles vary in length from 3.5 to 4 calibres and in weight from 150 grains (calibre .256 inch) to 245 grains (calibre .315 inch), the former attaining a velocity of 2329 feet per second, the latter 1984. The old Springfield ball (calibre .45, weight 500 grains) of the U. S. service, with 70 grains of black powder attained a velocity of only 1300 feet, but the new weapon, recently adopted (calibre .30, weight 220 grains), propels a ball 2000 feet per second.

Effects of Modern Bullets on the Tissues.—Great care must be exercised in drawing conclusions from the experimental results obtained with reduced charges at fixed distances (La Garde,[1] Habart, Seydel) and on the cadaver. The differences between the velocity of rotation and angle of incidence with reduced charges at fixed distances and service charges at actual distances are marked. The tension of living muscles and fasciæ as compared with dead tissues, and the physical change from the semi-liquid fat of adipose tissue and of medulla to a more solid condition by the loss of animal heat, influences the results. The *velocity*, *form*, *size* of ball, and *time* the injury is inflicted after leaving the weapon modify the tissue-damage. Elastic structures, as skin, may be merely split; less elastic ones, as fasciæ, muscle, and bones, are more or less destroyed for a varying distance around the track of the ball. As Conner points out, the gross anatomical structure may limit the destruction, as in a muscle longitudinally traversed, when "the track may be traced with great difficulty or not at all," owing to the separation, not destruction,

[1] *Report of Surg.-Gen. of the Army to Secretary of War*, 1893, p. 73.

of the fibres. It has been confidently asserted that the old missiles produced more primary and secondary destruction of tissue than the modern balls. With service charges—unless actual experience in warfare invalidates the results of experiments upon human cadavers and living horses—the more "humane" effects of jacketed balls is doubtful. The zone of "explosive action" is increased, extending up to 500 yards,[1] while for the skull, as has been shown by Demosthen,[2] there is practically no distance up to 1300 yards or more where "explosive action" is not marked:

FIG. 121.

Wound inflicted at about 110 yards (from a recent foreign report).[3]

FIG. 122.

Wound inflicted at 1300 yards by steel-mantled ball (from a recent foreign report).

this is also in a measure true for the softer viscera and for the hollow viscera when containing much fluid.

[1] There is no such action exercised by *pistol-balls.*

[2] *Études experimentales sur l'action du projectile cuirasse du fusil Mannlicher, nouveau modele Roumain de 615 m.m.*, p. 40 et p. 51.

[3] By request of the gentlemen to whom the author is indebted for permission to use these illustrations the exact source is not credited.

If no bony resistance is met with, or but little—as cancellous bone, between 350 to 500 yards and 1500 yards—*i. e.* at the "middle distance"—the wounds are more apt to be perforations, without much comminution of bone and laceration of soft parts, than with the old balls. But if much resistance is encountered, the ball often does become deformed (see Fig. 123), and, while the bone-fragments may not be so widely displaced, there is no appreciable difference detectable between Fig. 121, where the injury was inflicted at about 110 yards, and Fig. 122, where the ball struck at over 1300 yards. At 1800 yards and over—the "zone of contusion"—jacketed balls are not deformed, while the bone-comminution may be extensive with comparatively slight displacement of the fragments. Perforation rather than lodgement is the rule at all ranges, but this may occur if much bony resistance is encountered, although highly improbable for the cranium. Hemorrhage is apt to be more free than with the old balls, vessels and nerves being clean cut rather than lacerated or even pushed aside, although theoretically the larger size and greater deformation of the soft ball tended to endanger the vessels more than a small, unaltered missile.

At least 10 per cent. of the German-silver jackets part entirely from their cores at ranges of from 100 to 2000 yards if bony resistance is met with. The steel jacket is less apt to strip, yet Fig. 123 (*e*, *f*, *g*, and

Fig. 123.

a, completely shattered after perforating a horse's thigh-bone at 220 yards; steel mantle stripped; *b*, ball with mantle torn off and rolled up, core deformed, after shattering human tibia at 60 yards; *c*, wholly disorganized ball, which destroyed middle metatarsal bone of horse at 660 yards, steel-mantled; *d*, ball which shattered a human femur at about 750 yards, steel-mantled; *e*, remains of steel mantle and part of core lodged in human femur, wound inflicted at about 1100 yards; *f*, *g*, fragments of mantle found near the orifice of the wound of exit at about 1100 yards' range, steel-mantled; *h*, piece of steel mantle split off by striking a dried horse's metatarsal at over 1300 yards; *i*, steel-mantled ball which perforated the internal femoral condyle and lodged beneath the skin at nearly 2200 yards. (Recent foreign report.)

h) shows that at over 1100 yards great deformation and stripping may occur. Ball-wounds are usually contused wounds, although laceration may be added. Grazing of surfaces or contusion without skin-penetration may occur with pistol-balls or even spent rifle-balls, but perforation or penetration with lodgement is most common. The wound of exit

with the old balls was apt to be larger and more irregular than that of entrance, but those made by the new balls, when they involve the soft parts alone, are about the size of the projectile, sometimes smaller, sometimes larger. Unless within the "zone of explosive action" the wound of exit is often not appreciably larger than that of entrance, even sometimes when a bone has been traversed. But within the "explosive zone" the difference is often very marked (Fig. 124). The

FIG. 124.

1 2

Wounds produced by steel-mantled ball at about 220 yards: 1, wound of entrance; 2, wound of exit (from a recent foreign report).

wound of entrance has often a contused, discolored margin, and is depressed, while that of exit is everted and "stellate, triangular, or linear." *Powder-staining*, owing to differences in powder, varies, the distance of the muzzle from the part having been in reported cases from two to ten feet. Whether any analogous marking will occur with the new powders remains to be shown. *Deflection* of the modern conical pistol-ball is unusual as compared with the old round ball, and this is still more true of the mantled rifle-ball. Moreover, it must not be forgotten that change of position of a part or the body after the reception of a wound may closely simulate deflection of the ball. One bullet may cause "from two to six or more wounds," or, if lodging, "three, four, etc."[1] (Fig. 125). Splitting of the old, soft-lead ball sometimes caused two wounds of exit, but this will rarely occur with the hardened pistol or jacketed rifle projectile. The truth that "*when a bullet has ceased to move it has ceased to do harm*" has but few exceptions. When lodged

[1] Conner, *Dennis's System of Surgery*, vol. i. p. 448. I would here acknowledge my great indebtedness for much information and many valuable facts to Prof. P. S. Conner's article on "Gunshot Wounds" in the work just quoted from.

in the brain it may primarily, or, by changing its position from gravity, secondarily, cause dangerous pressure-symptoms. Again, a ball may ulcerate its way into a hollow viscus or blood-vessel when in contact

FIG. 125.

Multiple shot-wounds of arms and back. The opening over the spine was produced by pressure, not by the ball (case in Cincinnati Hospital, 1884). (Conner, *Dennis's System of Surgery.*)

with one of these. Lodged in the soft parts, a bullet usually promptly becomes fixed by the development of a connective-tissue capsule, although sometimes a change of position is effected by gravity or muscular action. One wound usually indicates lodgement, but the missile may have passed out by a natural opening, as the mouth or rectum. Again, the old-fashioned round ball—still occasionally employed—sometimes carries ahead of it for a short distance into the tissues a pouch of clothing, upon the withdrawal of which the ball is extracted and may be overlooked.

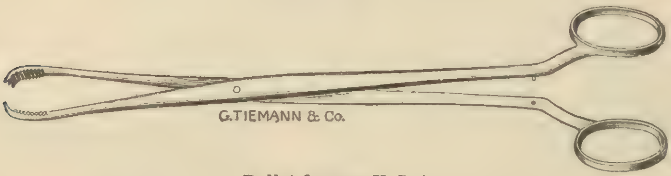
Determination of the Location of Balls.—*Palpation* and *exploration* with the finger or probe—electric or simple—are the means to be employed, and the X-rays when time permits. The disinfected finger is the best probe if the track be large enough. Pistol-balls which cannot be detected by palpation would better be *left* without further search unless the brain or a hollow viscus have been wounded. The only warrant for the enlargement of a wound is the probable lodgement of a fragment of clothing, since the finger alone can distinguish any textile fabric from the soft tissues.

A *bullet-probe* should be of metal and have as large an extremity as the ball-track will admit. Aluminum is light and useful for brain-wounds, but must not be placed in strong bichloride solutions. *Nélaton's* porcelain-tipped probe may

prove useful, but if a bone have been struck or traversed it may mislead, fragments of lead often adhering to the bone and marking the probe; moreover, a jacketed ball, unless approached from its butt end, *cannot mark* this probe, because no lead is elsewhere exposed. Girdner's *telephonic probe* seems to be the best of the electrical devices, but its exact value has not yet been determined.[1] Even when located it is not always advisable to remove balls. When their continued presence is likely to be more hazardous than their removal, operate: when this is in doubt and much damage will result from their extraction, let any missile alone. Extraction may be effected through the track of the ball or by a counter-opening, being guided by anatomical conditions and the superior facility of manipulation afforded by one method over the other. Fixation while being cut upon and free exposure are requisite when removing a ball by counter-incision. Many patterns of bullet-forceps have been invented, the U. S. A. patterns (Fig. 126) being the

FIG. 126.

FIG. 127.



Bullet forceps, U. S. A.

best, but except when extracting a ball through the wound-track an ordinary hæmostatic forceps usually suffices; if imbedded in a bone, an elevator should be used.

Hemorrhage.—This may be free, but is speedily arrested by natural processes unless a vessel of some magnitude is opened; but a large proportion of deaths from gunshot wounds result from primary hemorrhage caused by wounds of the great vessels. It is surprising, in exceptional cases to see how such wounds as those of the jugular, carotid, vertebral,[2] subclavian, external and internal iliac, etc. may not prove fatal for hours or even days. Probably the new bullets will give rise to more severe primary hemorrhage, while asepsis will lessen the frequency of secondary hemorrhage, which is largely dependent upon sepsis.

Pain.—This is variable, but unless a large nerve is struck it is dull or tingling, or like a smart cut with a cane. During great mental excitement no pain may be at first noticed.

Shock.—Although ball-injuries involving the brain, spinal cord, abdomen (solar plexus)[3] are usually attended with marked shock, this

[1] Park, "Some Considerations concerning Location and Detection of Missiles," *Medicine*, June, 1895.

[2] The writer has seen one case where the jugular vein, carotid, and vertebral arteries were wounded, and successfully operated upon by a colleague more than two days after injury, death eventually resulting from cerebral softening.

[3] Injuries of the basal ganglia, cord above the phrenics, the medulla oblongata, and the solar plexus, especially with modern balls, are probably instantly or almost instantly fatal, so that after such wounds it may safely be affirmed that the individual had been incapable of inflicting harm upon himself or others—a point of medico-legal importance.

is not invariably true. The author has seen marked symptoms from a comparatively trivial wound of an extremity, and after pistol-ball wounds of the brain or abdomen but little disturbance.

PROGNOSIS.—This depends upon the size of the missile, its velocity, the parts injured, and the degree of asepsis observed during *the first examination and dressing*, for, as Nussbaum justly observes, "the fate of a wounded man is in the hands of the surgeon who first attends him." *Cæteris paribus*, a pistol-ball wound of the same structures will not be so dangerous as that inflicted by the bullet of a military rifle. The primary dangers of shock and hemorrhage being survived, sepsis with possible consequent secondary hemorrhage is alone to be feared; hence the early aseptic treatment possible in civil practice renders gunshot injuries less fatal than those received in war. The majority of bullets being aseptic, the wounds they inflict will usually remain so, unless fragments of clothing or an unclean finger or instrument become a vehicle of infection. Theoretically, germs may reach a wound by way of the circulation, having gained access thereto by a distant infection-atrium. In practice this can be ignored. Proper disinfection of the environment of the wound, with rigid exclusion of all infected instruments, hands, and sponges, must be enforced in civil, and so far as possible in military practice, since experience demonstrates how much gunshot mortality can thereby be diminished.

Injuries by large shot or fragments of shell or objects set in motion by the impact of shot produce avulsions of limbs, extensive lacerations, or disorganization of a limb, leaving the skin almost or completely intact. These latter injuries usually result from the impact of so-called "spent shot." Large fragments of shells, stone, the point of a sabre, or even cannon-balls, may be lodged in a limb and their presence be unsuspected.[1] When such injuries are severe enough to demand amputation the limb must be removed well above the apparent limits of disorganization, otherwise sloughing will surely follow.

Small-shot Wounds.—These include all those not produced by bullets proper, even "buckshot." At close range a charge of the smallest shot will act as a solid mass, making a large track through the soft parts and the bones. If the vascular supply is not too extensively destroyed by laceration of the soft parts, even with free comminution of bone, the part can often be saved, but when serious damage to vessels and nerves also exist it is a grave question whether the limb will be worth saving at the cost of great peril to life. Conservatism is more warrantable for injuries of the upper extremity than the lower, because a hand on a maimed arm is valuable, while a sound foot on a leg incapable of bearing weight is only a useless incumbrance.

Typical or atypical resection can often be substituted for amputation, especially for injuries of the elbow- and shoulder-joints. If the shot-charge is received at a greater distance than a few feet, the destruction is rarely such as demands operation other than removal, when possible, of shot, loosened fragments of bone, shreds of clothing, etc.[2] Of course eyes may be destroyed, the larynx wounded, the great cervical vessels be perforated, or even the spinal cord be severed by a single small shot fired at a distance.

[1] Larrey reports such a case where a five-pound ball was imbedded in the thigh. Larrey suspected its presence from the weight of the part.

[2] The author's assistant in his presence and under his direction removed a large piece of newspaper and five hundred shot from the axilla of a patient, the charge being received at only about two feet distance, and yet no blood-vessels or important nerves were damaged.

General Considerations as to Treatment.—*Asepsis* should be the one end in view after any hemorrhage has been temporarily arrested. *Disinfection of the surrounding area* must be carefully effected, after which any necessary exploration of the wound may be made, hemorrhage permanently arrested, and foreign bodies, including bullets, removed if deemed advisable. Disinfection of the ball-track should *only* be done when it has been explored or if it is an extensive one, as the wound of exit sometimes is within the "zone of explosive action." Asepsis is favored by minimizing further damage to the tissues by securing rest for the parts by splints, etc. Patients wounded by modern pistol- and rifle-balls will usually recover if asepsis is maintained, unless some complication, as a serious visceral wound, coexists. Healing of the ball-track is usually said to commence in its central portion and proceed thence toward the wounds of entrance and exit, the former commonly healing last. When only the soft parts are compromised, aseptic healing often occurs or only a little pus is formed: this may even occur when bone lesions coexist.

If symptoms of infective inflammation appear later, as this often results from lodgement of infected foreign bodies, such measures should be adopted as would be indicated for similar conditions originating otherwise than from ball-wounds. The surgeon will be guided as to amputation or resection or conservatism for extensive destructions of extremities by small shot, cannon-balls, fragments of shell, or "explosive action of bullets" by precisely the same indications as would govern his action in railroad or machinery accidents productive of the same extent of injury to bone and soft parts. The constitutional treatment must be that of any injury of the same magnitude. Undue oozing, not arising from vessels of a magnitude demanding ligation, can be checked by hot water, cold, or elevation and compression, these last two often availing even when a large vein is involved. Wounds of large vessels—vein or artery—must be treated by ligation at the point of injury. The question of amputation for wound of both artery and vein must be decided by the extent of concomitant laceration of soft parts and consequent risk of gangrene from destruction of the collateral vessels. In secondary hemorrhage—usually the result of sepsis—the wounded vessel must, if possible, be tied in the wound above and below the lesion with any collateral vessel opening into the segment included between the ligatures: if this cannot be done, tie the vessel above, but as near the wound as possible. While compression, especially when the bleeding comes from the distal end of an artery or complete division of a partially divided artery, has sometimes succeeded, nothing short of ligation should satisfy the surgeon when this can be accomplished. If the first bleeding has been severe, interfere actively; if not, and the case can be under constant professional watching, in selected cases delay is advisable, because no further bleeding may occur.

Injuries of Soft Parts.—The *skin*, struck at a proper angle, may be merely grazed, and if the ball be "spent" a mere linear contusion results; but if moving with more velocity or at a different angle, the ball may just penetrate the integument. An appearance simulating the linear bruise inflicted by a severe cut with a whip follows the passage of a ball between the skin and deeper structures. The subsequent destruction and separation by sloughing of the tissues after such a wound will leave a depressed groove, and later a similar scar. Grazing by cannon-balls or large fragments of shells, or more commonly impact of a nearly "spent" large projectile, may leave the skin intact, but disorganize all the other tissues of a limb, or the viscera if the walls of a cavity be concerned. With dry aseptic dressings skin-grazes or contusions, producing even sloughing of a portion or the whole thickness of

the skin, will heal readily without suppuration. Deflections even of pistol-balls by *fasciæ* are now rare, and modern rifle-balls are never thus turned from their course. The openings made by perforations of fasciæ being due to separation as well as division of fibres, partial closure takes place, rendering it difficult to follow the track of the ball and also interfering with drainage. Imperfect healing of fascial wounds may lead to hernia of muscle,[1] but this will be much less likely to follow wounds inflicted by the modern small-calibre missiles than with the old large balls. Severe damage to muscles is only caused when balls strike at short range—*i. e.* within the zone of "explosive action."[2] Wounds parallel to the course of muscular fibres often separate rather than divide them; hence the difficulty or impossibility of following such a track with a probe; but passing at right angles to the fibres, their division must take place. Large shot or fragments of shells produce much destruction and sloughing, often causing serious deformities by scar-traction. The belly of a muscle may be ruptured by a bullet striking, but not penetrating, its tendon. *Tendons* may be perforated or divided or a segment may be removed. In the future bullets will rarely simply contuse vessels, but partial or complete division will be the rule. Secondary hemorrhage, the formation of an aneurism or an arterio-venous aneurism —when an adjoining artery and vein are injured—may follow slight vascular wounds. *Nerves* more commonly escape complete division than vessels, but partial division and contusion often lead to late trophic changes with partial or complete abolition of function.

Injuries of bones and joints comprise nearly one-fourth of military gunshot wounds, but are much less common and severe in civil life, because usually inflicted by small pistol-balls moving with comparatively low velocities. Pistol-balls and spent rifle-balls may simply contuse bones, the result depending upon whether merely subperiosteal effusion is produced or the vessels in the bone-tissue are ruptured. In the latter event necrosis may result, especially if infection occurs. Bone-contusions will probably be rare with modern projectiles, and under aseptic treatment should recover without local or general infection, thickenings, or neuralgias, as was so common in the past.[3]

Bones may be fissured, divided into two or more fragments, or may be partially or completely perforated. Slight fissuring is doubtless often overlooked, owing to the difficulty of diagnosis. The fissure may extend obliquely or transversely across a bone, even producing complete fracture without rupture of the periosteum. The fragments may never separate or attempts at walking may later displace them. Most ball-fractures are by penetration; a portion of the osseous tissue, being driven in or more or less finely pulverized, is scattered along the ball-track (Fig. 128), lines of fracture usually radiating from the main focus.

The *comminution* varies, being in inverse proportion to the velocity of the ball, but in a long bone does not usually extend through the epiphyseal ends. The fragments may be completely detached or partially adherent by periosteum. Pistol-balls may imbed themselves in bone, but this accident will be excessively rare with rifle projectiles. Except at short ranges modern balls comparatively clearly perforate long bones at or near their cancellous ends, with little or no fissuring (Figs. 129, 130). Flat bones are more apt to be perforated with extensive shattering. Within the "explosive zone," when a resistant bone is struck, there will be

[1] See Chap. XXII. [2] See Figs. 124, 128. [3] Conner, *op. cit.*

great loss of bone-tissue, the fragments being driven in all directions, backward as well as onward and to either side, producing widespread pulpification of the soft parts (see Fig. 124). The wound of exit is really a bursting outward of the skin by the force acting from within, the track being conical, with the apex at the site of the fracture. Sometimes the wound exceeds six inches in length and four in

FIG. 128.

Shattering of humerus at long range with modern projectile; fusible metal cast showing extent and character of laceration of soft parts (from a recent foreign report).

breadth, bone-fragments in addition occasionally piercing the skin outside the main laceration.[1] At from 1200 to 1500 yards perforation with marked comminution is apt to occur, *but the fragments are not much displaced.* Beyond these ranges, so long as the ball possesses momentum enough to fracture, comminution *with displacement* is the rule. A ball crossing a bony crest or at a tangent to a curved surface may cut a clean groove, but may in addition fissure. A soft-lead ball may split on a bony crest or even the convexity of the cranium. This accident will rarely occur with hardened pistol-balls, and will be still more improbable with jacketed rifle-balls. Fracture by penetration or perforation may be inferred if bone-fragments or dust be found in either wound, especially that of exit, and if this be decidedly larger, than that of entrance. Of course, if the ordinary symptoms of fracture are detectable, the diagnosis is clear. When the direction pursued by the ball renders it nearly certain that fracture by penetration exists, it is safer to act upon this hypothesis, lest displacement with additional injury be produced by manipulation.

TREATMENT.—Render the wound-orifices and surrounding skin

[1] See Conner, *op. cit.*

aseptic, and then the accessible portion of the track; dress and *immobilize* the parts.

More extensive bone-injuries require the same preliminaries, followed by aseptic removal of all completely detached fragments, moulding into place of attached fragments, disinfection, if deemed necessary drainage, careful fixation of the parts, and antiseptic dressings. When an

Fig. 129.

Wound of entrance at about 660 yards; perforation of cancellous bone with but little fissuring (from a recent foreign report).

Fig. 130.

Wound of exit of specimen shown in Fig. 129 (from a recent foreign report).

impacted ball can be easily reached, it should be removed, but if much additional injury would result from its extraction, it had better be left, for although no heat sufficient to render a ball aseptic is developed either during firing or by its passage through the tissues, yet the majority of projectiles "are either sterile or free from septic germs." Great destruction of bone and soft parts by balls wounding within the "zone of explosion," those by charges of small shot at short ranges, etc., must be treated as similar compound fractures otherwise induced. If the destruction of bone and soft parts is so great that the limb must prove useless if saved, or if the main vessel or vessels are divided, with such damage to the tissues through which the collateral circulation must be established that gangrene will occur or repair almost certainly fail, *amputation* should be done. *When in doubt*, especially in civil practice, tie all bleeding vessels, extract loose bone-fragments, replace attached ones, disinfect, drain by numerous counter-openings and tubes, and immobilize, amputating later if gangrene or infective osteomyelitis

occur. These rules require modification in military practice because prompt and effective antisepsis with proper after-care of the wounded is so often impossible.

Wounds of Joints.—Wounds of the soft parts over a joint may, if they become infected, secondarily set up *intra-articular* trouble. Wounds of *bursæ* will lead to similar results if they communicate with a neighboring joint, as they so often do. If the wounds of entrance and exit indicate perforation of a joint by a modern conical ball, such an injury may be confidently affirmed. A ball *traversing a joint* usually perforates, crushes, splinters, or grooves one or all of the component bones, but the synovial membrane may alone be penetrated. Extra-articular bony fissures may tear the synovial membrane, or secondary penetration may result from septic ulceration extending from an infected fissure.

Diagnosis.—With free destruction of soft parts, as by a fragment of shell, this is easy. Extensive bone-comminution near a joint, followed by rapid distention of the articulation from accumulation of blood, escape of bloody synovia, or the presence of bone-dust or fragments in the wound of exit, readily decide the question of joint-wound. In the absence of these symptoms the relative position of the wounds of entrance and exit and the free escape of synovia must be depended upon. The probe should be avoided as a means of diagnosis. *When doubt exists treat the case as one certainly involving the joint.*

Prognosis.—Death should rarely occur from an uncomplicated joint-wound in civil practice, but the prompt and successful employment of asepsis in military surgery is so often impossible that the mortality in the past has been as high as 12.9 per cent. for mere wrist-joint wounds. Modern methods will much diminish this mortality, as well as the frequency and extent of the ankylosis so common formerly when conservatism was attempted.

Treatment.—This may be conservative; excision may be done or the limb be amputated. *Conservatism* means the removal of all foreign bodies, including the bullet if readily accessible, and all completely detached fragments of bone. If much blood fill the joint, free drainage must be provided, and voluminous antiseptic dressings applied, with fixation of the articulation. Formal excision as a primary measure has not given as good results as the conservative procedures just advocated.

Primary amputation is only demanded when such extensive destruction of the hard and soft parts render it certain that the limb, if saved, will be only an incumbrance, or when both direct and collateral circulation has been practically destroyed by injury of the soft parts, because a main vessel can be ligated or an important nerve sutured if the collateral circulation is unimpaired. Suppurative arthritis requires free incisions, disinfection, drainage, and immobilization. If these measures fail, possibly excision or amputation may avail to save life. The different methods of treatment suggested are not equally applicable to similar injuries of all joints. The special indications for each articulation will be considered in Chapter XXXIV.

Wounds of the Head.—The scalp may alone be wounded, contusions, lacerations, or penetration, and lodgement resulting. Pistol-balls often lodge, especially in the temporal muscle, but rifle-balls rarely if ever.

Treatment.—The probe or palpation will usually locate the ball.

When imbedded in the temporal muscle, pain on moving the jaw or upon pressure over the zygoma may guide the surgeon.

Considerable hemorrhage may occur from wounds of the temporal or occipital arteries, or a cephalhæmatoma may form, presenting some superficial resemblances to a depressed fracture. If absorption of these blood-effusions does not take place, antiseptic aspiration or incision is indicated. Unsuspected intracranial lesions produced by impact of the ball on the cranial vault may prove serious, but mere osseous contusion, treated antiseptically, should no longer give rise to the neuralgias, headaches, etc. so common in the past.

Injuries of the Cranial Bones.—*Contusions* may be produced by nearly-spent balls or those striking at a tangent, but with the new bullets such lesions will be rare, fracture or grooving being nearly certain. If asepsis be maintained, usually only plastic exudate follows, although quiet necrosis may result. If infection occurs, osteomyelitis may cause necrosis of the external table alone or more rarely of the whole thick-

FIG. 131.

Complete shattering of a fresh head by a mantled ball, striking at about 55 yards; scalp reflected (from a recent foreign report.)

ness of the bone. *Infective inflammation* of the *diploë* is a not uncommon sequence of contusion. This may cause subcranial suppuration, septic encephalitis, or general pyæmia. Fracture of the internal table of the skull is also possible. (*Vide*, also, Chapter I. Vol. II.)

DIAGNOSIS.—This may be made by inspection or the probe, but where the former is impossible it is safer to infer the lesion of the bone by the course of the ball, unless its removal or the arrest of hemorrhage demands exploration of the wound.

TREATMENT.—Strict asepsis, if instituted early enough, will prevent any septic complications. If these arise, incisions, removal of infected

bone, opening of cerebral abscesses, disinfection, and drainage are indicated.

Penetrating gunshot injuries cause more serious intracranial lesions than follow other traumatisms, that which appears but a mere fissure having often been produced by marked *temporary* depression of both tables, as shown by a tuft of scalp-hairs imprisoned in the capillary crack or a fragment of a ball lodged within the cranium.

Widespread shatterings, especially those involving the base, result from extension of fissures, conduction and amplification of vibrations by thickened bony ridges, and, owing to the semi-fluid structure of the brain, to hydrodynamic (hydraulic) pressure, so that the "zone of explosive action" for modern missiles exists at all ranges so far as the skull is concerned.[1] The *base* is seldom fractured by hydraulic pressure, although the ethmoid and the orbital plates of the frontal may yield. Pistol-balls rarely develop this pressure, but these same plates are sometimes thus broken. Sudden death, caused by disorganization or removal of large portions of the skull and brain by cannon-balls or charges of shot, etc., sometimes gives rise to *traumatic cataleptic rigidity*—*i. e.* post-mortem rigidity rapidly produced, which maintains the body in the position when struck.

The skull may be grooved without other penetration than that by concomitant fissuring. Fracture of the external table alone is very rare. In adults—for in young children none exists—the anterior wall of the frontal sinus may be perforated by a pistol-ball which remains in the cavity, no penetration of the cranial cavity occurring. The inner table around the wound of entrance, when penetration occurs—*i. e.* on the side of extension—is more freely shattered, while at the wound of exit, the same law holding good, the external table suffers more. Pistol- or spent rifle-balls may sometimes produce depression of the external table with crushing of the diploë, the vitreous table being uninjured. Again, the inner table may be broken in this way or by the tangential impact of a ball. Very rarely fractures resembling those produced by the corner of a bolt-nut or a large board-nail are seen, where a limited portion of the external table and diploë are driven down, but the internal table is extensively shattered—a variety of punctured fracture, as Conner justly terms it.[2]

Prognosis.—This is most serious, early death resulting in fully one-half from shock and hemorrhage. When the ball (pistol) was removed, according to Bradford, 33.33 per cent. recovered; when it was left, 46 per cent. Expectancy gave in 25 cases a mortality of 52 per cent. Wounds involving only the frontal lobes with lodgement of the ball seem less dangerous than those of the more posterior portions of the brain. *Cerebellar* lesions are usually rapidly fatal. Transverse wounds, passing laterally through or near the ear, are more dangerous than antero-posterior ones. Infective intracranial inflammations, leading to localized (abscess) or diffused suppurations and hernia cerebri are the late causes of death: these are avoidable if asepsis be secured. Division of one or more of the cranial nerves and various late perversions of cerebral function, as epilepsy, headaches, and insanity, are possible sequences, as after other head-injuries. Balls do not usually become encysted, but change their position in time by gravity. If while migrating they encounter portions of the brain governing important functions, serious trouble is sure to arise, even many years after injury.

[1] See Demosthen, *op. cit.*

[2] Dennis' *System of Surgery.*

Diagnosis.—This must be made by inspection, palpation, probing, or possibly by percussion. The aid of the X-rays may also be invoked.

Treatment.—As infection is the sole lethal cause if primary hemorrhage and shock do not cause death, disinfection and drainage are *the* indications. The wound or wounds should be protected by antiseptic compresses, and (preferably) the whole scalp carefully shaved and disinfected; finally the wound itself should be cleansed. Fracture or penetration having been determined by the proper means, a flap should be reflected and the damaged bone (probably infected) be removed, hemorrhage be arrested by ligation, forcipressure,[1] or possibly a gauze tampon. The wound of exit must be treated in the same manner. One drainage-tube, or two meeting in the centre of the track must be carefully introduced, and gentle irrigation with sterilized water employed. When the ball has lodged after the preliminaries described, it may be sought for by an aluminum probe or a medium-sized elastic bougie.

The effect of gravity should be invoked to aid the progress of any probe, because a false passage is so readily made through the cerebral tissue. Probably the *telephonic probe* would here work to most advantage. If the probe passes readily to the opposite side of the skull, careful palpation may reveal the presence of the ball beneath the scalp, a fracture, or an ecchymosis if the head has been shaved. None of these three conditions being found, trephining should be done over the end of the probe and the ball sought within the cranium above, below, to one side or the other of the opening. After the failure of such an amount of search as can do no serious injury to the brain, it is better to desist from further manipulations beyond depositing a drainage-tube in the track and carefully irrigating it. *Localizing* symptoms may indicate the *course* of a ball, but rarely its *location*, and unless detected very shortly after the reception of the injury are apt to be misleading, owing to slowly-extending hemorrhage. Even immediately after the wounding the localizing symptoms are often deceptive, owing to the widespread injury outside the actual ball-track. Voluminous dressings are usually requisite on account of the free escape of cerebro-spinal fluid. Fracture without penetration requires the treatment adapted to any compound fracture of equal severity.

Secondary hemorrhage must be treated by ligature of any bleeding vessel or by tamponade if trivial; if severe, by ligature of the main vessel when the bleeding point is not accessible, securing the external carotid rather than the common if this will arrest the hemorrhage. Fractures implicating the base must be treated as when produced by other causes.

Face.—Primary or secondary *hemorrhage* is the chief danger, although destruction of parts and extensive scarring may result, especially from small-shot wounds. Pistol-balls, except at short range, do not shatter the facial bones much, and probably the new rifle-bullets will not, at least in the middle ranges. Balls may pursue most erratic courses, penetrating the face to emerge by nostril or mouth, without doing any or but slight damage—traversing the orbit or mouth without injuring eye or tongue. Bullets travelling from before backward through the face often wound the brain, spinal cord, or great vessels. Transverse wounds, especially those involving the lower jaw, are often complicated by division of one or more of the larger vessels.

[1] Fine wire serres-fines, with attached ligatures, may be left *in situ* for days if ligatures cannot be made to hold. Cerebral vessels being deficient in sheaths, it is difficult to ligate them; only enough tension should be put upon the first half of the knot to occlude the lumen of the vessel.

Pistol-balls often lodge in the orbit, nasal fossæ, or antrum. Bullets passing through the back of the orbits may wound or divide one or both optic nerves. Those injuries of the supraorbital regions leading to blindness, formerly attributed to damage to the supraorbital nerve, are generally due to a fissure traversing the optic foramen and destroying the nerve. Furrowing or perforation of the tongue is not uncommon. Fragments of, or whole, teeth are sometimes driven into the tongue; more rarely the ball itself lodges. Although often productive of such swelling as to interfere with speech, deglutition, or even respiration, tongue-wounds are not usually dangerous unless the lingual artery be wounded.

Treatment.—Ligate vessels; extract teeth, pieces of bone, or a ball imbedded in the tongue; remove neither attached bone-fragments nor contused soft parts; mould the hard parts into place; maintain all *in situ* by sutures, antiseptic compresses, or tampons, or by interdental splints. Secure all the asepsis possible by irrigation, non-poisonous mouth-washes, and sprays.

Primary hemorrhage demands ligation in the wound when from a vessel of any magnitude; if not, antiseptic tamponade, deep suture—as in the tongue—or the cautery. When the wounded vessel is not accessible, tie the main trunk or trunks, as both linguals or facials, or even one or both external carotids. Secondary hemorrhage must be treated on the same lines, but, owing to the condition of the wound, ligation must usually be done at a distance. *Dyspnœa*, when serious, must be treated by free incisions into a swollen tongue; possibly laryngotomy might become requisite where the wound involves the base of the organ. Later, plastic and mechanical surgery are often demanded to relieve the deformities resulting from extensive loss of soft and hard parts.

Neck.—Wounds in front of the sterno-mastoid muscles must, when deep, compromise important structures, as the trachea, œsophagus, great vessels, and nerves, with all their primary and remote dangers. Those posterior to these muscles, although possibly involving the spine, are usually only muscle-wounds.

Prognosis.—Hemorrhage, often late, and suppuration, which unless early evacuated will extend, directed by the cellular planes into the thorax or axilla, are the chief dangers.

Treatment.—Primary hemorrhage (rarely seen) must be treated by ligation in the wound, if possible, when arterial; by compression if venous, unless the deep jugular be wounded, when ligation should be done. Too often the vessel cannot be secured in the wound, when both carotids should be exposed, and if compression of the external arrests the bleeding it should be tied; if not, the internal must be secured. Wound of the vertebral above the sixth cervical vertebra can better be controlled by efficient tamponade. Wounds of more than one vessel are not unusual, as carotid, jugular, and vertebral, and with a small external wound, as by a pistol-ball, such an injury of the great vessels has been found compatible with several days of life, a traumatic aneurism or arterio-venous aneurism forming. If a ball so lodge as to cause irritation or paralysis of nerves by pressure, its removal will probably ameliorate or relieve the trouble. The larynx or trachea may be merely contused by a bullet, causing pain, dyspnœa, and bloody expectoration, with cough. If penetrated, *emphysema* or the external escape of air is

superadded. When the œsophagus or pharynx is also opened, food is apt to escape from the wound, although this may be due not to an abnormal opening in the gullet, but to improper action of the epiglottis, so common after tracheotomy. Hemorrhage into the trachea, or, occurring later, œdema glottidis, may cause death. Dangerous pressure may also be exerted from without upon the trachea by blood or inflammatory exudate. After recovery impairment of the voice is apt to persist. Ligation, suturing, tamponade, or the actual cautery may become requisite to arrest bleeding if the thyroid body is wounded.

TREATMENT.—Remove the ball if lodged, secure asepsis for the wound, and employ early intubation or tracheotomy if the respiration is seriously interfered with. Suture, or, if this is impossible, plugging, of any œsophageal or pharyngeal wound is necessary to prevent infection, employing for the same reason the œsophageal tube for feeding. Later, necrosis of cartilage may occur, aërial fistula may persist, or more rarely stricture may form.

Spinal Column.—The ball or fragment of shell may contuse a vertebra, fracture any portion of it (usually a spinous process), wound the meninges or cord, or be a complication of cervical, thoracic, abdominal, or pelvic perforation.

SYMPTOMS.—*Shock* is great. When the cord is damaged there is impairment or destruction of function according to the location and extent of the primary contusion or laceration or the secondary compression by blood and inflammatory exudate. Very rarely cerebrospinal fluid escapes from the wound, proving that at least the membranes have been opened. *Hemorrhage* external to or within the membranes, and possibly within the substance of the cord, if slight may, after temporary pain and paralysis, end in complete recovery. Large effusions are apt to end in *infectious myelitis*, the chief danger in all spinal injuries. Evidences of severe and lasting damage to the cord when life is spared are most commonly due to bone-fragments, or, exceptionally, to lodgement of the ball.

PROGNOSIS.—Where the membranes have been opened, much worse perforated, some compression or laceration of the cord must result. In military surgery *infective myelitis* usually destroys life, but in civil practice cases receive effective assistance so much sooner that the prognosis is somewhat better, although from the difficulty of securing asepsis unless the wound be below the cord proper—*i. e.* involving only the cauda equina—the outlook for life is most gloomy.

Contusions of the membranes and cord, causing slight extra- or even intradural hemorrhages, are recoverable, but even when the osseous lesion is apparently limited to a spinous or transverse process "chronic inflammations and scleroses" may be expected to follow from slight concomitant lesions of the membranes or cord, which will result in neuralgias, impairment of function of the bladder, a limb, etc., but "which may not perhaps be manifested for years."

TREATMENT.—*Asepsis* must be striven for and maintained, separated bone-fragments or the ball extracted, drainage be instituted, because asepsis is doubtful, and fixation of the spine should be effected. Where early symptoms of pressure on the cord suggest the probability that the ball, bone-fragments, or blood-clot is causing the paralysis, or, later, that exudate or callus is destroying function, a more or less formal lami-

nectomy is indicated in cases not complicated by serious lesions elsewhere.

Thorax.—Thoracic wounds may be *non-penetrating* or *penetrating.* The latter may be complicated by fractures of the ribs, sternum, vertebræ, clavicle, or scapula, and by wounds of the axillary and scapular vessels, many of these last proving rapidly fatal. *Any apparent deflection of modern balls from a straight line is due to the difference between the position when the wound was inflicted and when it is examined.* Contusion of the pleura or lung, evidenced by shock, temporary dyspnœa, and pain during respiration, is not uncommon.

Owing to the great elasticity of the thorax, blows from fragments of shell, or contact with spent cannon-shot may produce lacerations of lungs, heart, or the great vessels without any fracture. Marked shock, collapse, and death, if the lacerations are extensive, follow such accidents. Associated bone-lesions add to the gravity, because of the greater risk of infection. Mere penetration without perforation is now very rare, even pistol-balls commonly traversing the thorax to lodge, perhaps, outside in the overlying muscles. If infection can be avoided, unless some necessarily fatal lesion has been inflicted by the ball, recovery is more apt to follow a perforating than a penetrating injury with lodgement of the missile, because no foreign body is left in the chest.

Diagnosis.—From the small size of so many modern missiles, this is often difficult, neither protrusion of lung taking place nor inspiration and expiration of air occurring through the wound during the corresponding acts of respiration. *Emphysema* may occur in non-penetrating wounds from air insinuating itself among the tissues during the alternate expansions and contractions of the thoracic wall. If a line connecting the wounds of entrance and exit would traverse a lung, such an injury may be confidently affirmed, as modern balls do not run for long distances beneath the thoracic soft parts. *Pain*, restriction of the freedom of respiration, hæmoptysis in varying amount, and cough accompany penetrating and perforating wounds of the lungs. *Compression of the lung* by accumulation of air or blood in the pleural cavity may be detected by the characteristic physical signs. Shock and collapse are usually greater that in non-penetrating wounds. *External hemorrhage*, when severe, comes from the cervical or axillary vessels. *Internal bleeding* comes from the intercostals, internal mammary, the large pulmonary vessels, the great vessels, or the heart. When from any of the three latter sources, the hemorrhage rapidly proves fatal. Bleeding from the lung-tissue is rarely of much moment.

If a ball lodge—an unlikely accident in the future—it may remain harmlessly encapsulated for years, may ulcerate early or late into a bronchus and be coughed up, into the œsophagus and pass *per anum*, or pass into the pleural cavity. Even bone-fragments imbedded in the lung do not add materially to the danger, provided infection is prevented.

Prognosis.—Asepsis should lessen the mortality of the past by diminishing the frequency of empyema, lung-abscess, and mediastinal abscesses which formerly caused the high death-rate. The not uncommonly associated wounds of the abdomen markedly increase the mortality. Prolonged intrathoracic suppurations may end in recovery, but with sequelæ akin to those seen after the same conditions of non-traumatic origin.

Treatment.—*Asepsis* and *immobilization of the chest*, with treatment

appropriate for any traumatic pleurisy or pneumonia, is all that is requisite for non-penetrating wounds—*i. e.* those involving only the parietes—contusions or flesh-wounds. In penetrating and perforating wounds shock must be combated, and the ball should only be sought for if felt lodged in the chest-wall. *Sterilization of the wound* must be effected, and after any bleeding has been arrested by ligature, forcipressure, or possibly tamponade, the thorax must be put at rest by strapping or a plaster-of-Paris jacket. Aspiration may be done for extensive hæmothorax producing pressure, but this, as well as empyema, is better treated by excision of a portion of a rib to secure free drainage and the removal of any foreign bodies, as a bullet, fragments of bone, clothing, etc. Concomitant fractures present the same indications as when occurring elsewhere. Pulmonary, intestinal, or omental herniæ through the lower intercostal spaces must be restrained by pressure.

Heart.—*Contusions*, *penetrations* of the *pericardium*, penetrations and the slighter perforations of the *heart-muscle* alone come under treatment.

Contusions result from nearly spent balls which retain enough momentum to tear the pericardium and then bruise the heart. Only a "*tangential blow*" can wound the pericardium alone. Lodgement without penetration, and penetration of one or more cavities with lodgement of a missile, will only follow pistol- or small-shot injuries. Concomitant lung-wounds are common.

Prognosis.—Wounds of the base are usually promptly fatal, even when caused by small balls, but when resulting from the modern rifle-balls are invariably so from shock, or shock and hemorrhage combined. When the base escapes, temporary recovery, lasting for from days to years, sometimes occurs, bleeding being arrested by clot and contraction of muscular fibres until more permanent repair is effected. More commonly death ensues within a short time from the accumulation of blood in the pericardium arresting the heart's action, rather than from actual loss of blood, although this may be profuse. After so-called recovery permanent damage of the organ remains.

Diagnosis.—Any lesion of the heart produces the most profound shock—even fatal—with irregular action and modification of the heart-sounds—*i. e.* bruits. Increase in area of the *dulness on percussion* denotes bleeding into the pericardium. *Pneumo-pericardium* will cause a reversal of this symptom—diminution of dulness.

Treatment.—Relief of shock, arrest of hemorrhage, asepsis, removal of the pressure of accumulations of blood and exudate in the pericardium by incision or aspiration comprise all the expedients usually available. Suture will hardly be feasible, however possible for an incised wound.

Abdomen; Solid and Hollow Viscera.—The *parietes*, especially in civil life, may be wounded without penetration of the cavity, although this is exceptional. *Contusions*, usually produced by contact with spent cannon-balls or blows from fragments of shell, often mean serious laceration of the viscera or rupture of the muscular parietes, possibly ending in gangrene of the abdominal wall.

Prognosis.—In the absence of visceral lesions recovery should take place.

Treatment.—Contusions require aseptic dressings for any abrasions and early evacuation of pus and sloughs if these form. Flesh-

wounds of the parietes require only that which is appropriate for similar wounds situated elsewhere. Laparotomy is requisite when visceral laceration exists.

Penetrating and Perforating Wounds.—Although 3 to 5 per cent. of wounds pursuing an antero-posterior direction are free from visceral lesions, it is safer to consider that such complications exist, especially with wounds traversing the abdomen from side to side. The probable order of frequency of visceral injury is—small intestines; large intestines; liver; stomach; kidney; spleen; pancreas. Usually *multiple* lesions exist, involving omentum, mesentery, lung—when the ball enters through or emerges from the thorax—or the large vessels, in addition to strictly visceral lesions.

PROGNOSIS.—This depends in each case upon the extent and nature of the lesions; hence no specific direction as to prognosis can be given. The *death-rate* varies from 24 to 87 per cent., and results primarily from shock and hemorrhage, later from septic peritonitis.

Although the dangers of hemorrhage and sepsis can in the future be measurably diminished, yet the mortality will always remain high. Wounds of the stomach and large intestine are less lethal than those of the small bowel, and perforation of any hollow viscus is less dangerous when the organ is empty at the time of injury.

DIAGNOSIS.—*Protrusion* of bowel, omentum, spleen, or the escape of bile or fæces render diagnosis easy, but such indications are rare even with the old-fashioned bullet of large calibre. In default of these signs exploration by incision of the ball-track or laparotomy can alone render penetration, much more visceral lesion, certain. The relation of the wounds of entrance and exit in complete perforations usually decides the question of visceral penetration. *Vomiting* or the passage of blood *per anum* or *urethram*, the physical signs indicating rapid accumulation of fluid—*i. e.* blood—in the belly, loss of liver-dulness from free air in the abdominal cavity, are, when all are present, positive signs of visceral lesions. *Bloody vomit*, stools, or urine might indicate mere contusion, but free peritoneal air can only mean bowel-wound, and rapid accumulation of intra-abdominal fluid, bleeding from omentum, mesentery, great vessels, or from a solid viscus. The hydrogen-gas test before laparotomy, when successful, will demonstrate intestinal wound, but its failure does not preclude the possibility of such an accident.

Careful *exploratory incision*, opening up the wound-track, or in the median line when the wound is a transverse one, may be necessary, and is a *safer* diagnostic procedure than exploring with the probe or finger. The direction pursued by the ball, the point of entrance, shock, bloody urine, with the possible external escape of urine if the wound be situated in the back, will usually indicate a kidney-wound.

Serious intra-abdominal lesions, according to Redard, always produce a depression of temperature for from four to many hours, and when such subnormal temperature is detected it is strong presumptive evidence of penetration with visceral wounding. Peritonitis, usually developed after the first eighteen hours, may show only slight rise of, or even depression of, temperature, but the pulse is usually notably frequent. In many cases, however, the ordinary complexus of symptoms indicative of peritonitis are present.

TREATMENT.—This must be either *purely medical*, by opium, small amounts of fluid food, and maintenance of local and general quiet, or

operative. The mortality with the expectant treatment, as given by numerous observers, varies from 59.4 to 65 per cent., the figures given by Reclus being so extraordinarily favorable as to throw suspicion upon their accuracy. The mortality after operation varies from 66 per cent. to 78 per cent., but it must be remembered that the operated cases are usually those worst injured.

Early operation, arresting bleeding and fecal extravasation or removing this and draining, *gives the best result*, success almost never attending section after development of generalized peritonitis.

In military practice the difficulties of making a proper laparotomy may prove insuperable, but when possible must be attempted. In civil practice where penetration is certain section should be done, lest some foreign body, as a piece of cloth, be lodged, although no visceral wounds exist. Such action is all the more imperative if fæces, bile, or urine escape externally. Severe and rapidly increasing collapse usually means internal hemorrhage, which if not arrested by art will prove fatal. As balls traversing the abdomen from side to side on a level with and below the umbilicus almost invariably damage the small intestines, such wounds indicate exploratory section. Although wounds resulting from 22-calibre balls involving the empty stomach, the liver, kidney, or colon are sometimes recoverable from, laparotomy done by a skilled hand is safer than conservatism. When the present army bullet strikes within the "zone of explosive action," laparotomy will always be demanded when circumstances permit. Hemorrhage or urinary extravasation alone demands operation for kidney-wounds inflicted from behind when the peritoneum is intact. Kidney-bleeding may be treated by ligature or suture, as practised by Tiffany, with or without previous resection of the damaged portion of the organ, leaving nephrectomy as a last resort.

Technique.—If doubt exists as to *penetration*, determine this point by careful enlargement of the ball-track. This may settle the point where the abdomen should be opened, but a median incision is that which gives the best access to the organs most commonly injured. After having opened the abdomen, any bleeding should first be arrested by ligature, compressing the aorta as a temporary measure while the bleeding vessels are being exposed, or sterilized gauze packing may be employed for the same purpose. The *bleeding* usually comes from the *mesenteric* vessels or from one of the *solid viscera*, although the intrapelvic vessels, an intercostal or the internal mammary artery, may be its source. The small and large intestines must next be systematically examined, inch by inch, covering the protruded parts with towels or pads wrung out of hot sterilized salt solution, returning each loop as soon as examined. Every opening must be closed transversely, as detected, by fine silk Lembert sutures. *Contused spots*—as shown by Park—will slough, and must therefore be treated as if wounds. When closure of several closely contiguous wounds would constrict the lumen of the bowel too much, *resection* with end-to-end or lateral anastomosis must be done. *Rents in the omentum* should be closed, bleeding vessels ligated, and damaged omentum removed after tying off in sections. Wounds of the *stomach*, *large intestine*, *urinary bladder*, and *solid viscera* or *gall-bladder* must next be sought for, the three first being treated by suture, the last by suture or plugging with gauze.

Inflation with hydrogen gas or air may aid in detecting intestinal wounds, but is not infallible, fæces sometimes plugging the openings. Suture works best for liver- or kidney-wounds, plugging with gauze and drainage for those of the spleen and pancreas. Splenectomy and nephrectomy are only demanded for extensive lacerations. Repeated flushing of the abdomen with hot sterilized salt solution

during and after the manipulations is advisable. Drainage must depend upon the amount of peritoneal fouling with fæces, urine, etc., the freedom from hemorrhage, and the probability of subsequent extravasations of urine from a wounded kidney or of bile from a damaged liver.

The *after-treatment* consists in combating shock, careful alimentation, and, later, the draining off by the intestines of septic products by saline purgatives, differing in no material way from that adopted after other laparotomies involving intestinal lesions. *Fecal fistula* following wounds of the colon is a rare accident, and if spontaneous healing does not occur —a very common result—operative interference is indicated. *Rectal* wounds which are not part of other intra-abdominal lesions are chiefly of moment from the probability of widespread suppuration and sloughing from infection. If the wound be below the peritoneal investment, it should be treated by disinfection of the wound and bowel, quiet of the latter induced by opium, and incisions for drainage if burrowing of pus occurs. Rectal wounds opening into the peritoneal cavity demand laparotomy and suture, or possibly tamponade with drainage, if the wound for any reason cannot be sutured.

Genito-urinary Apparatus.—*Bladder-wounds* are often complicated with lesions of the pelvis, pelvic vessels, and rectum. An empty bladder is seldom wounded. Partial penetration by guttering sometimes occurs, which usually soon becomes complete by ulceration. When the portion uncovered by peritoneum is wounded, the consequences are much less serious than when the peritoneum is involved.

PROGNOSIS.—This depends upon the associated lesions, especially opening of the peritoneal cavity.

SYMPTOMS.—Those pecular to *bladder-wounds* are irritability of the organ and possibly the rectum, hæmaturia, and the escape of urine by the external wounds—a rare occurrence except after wounding with balls of the largest calibre. *Hæmaturia* may also result from wounds of the urethra, ureter, or from simple contusion of the bladder. Micturition may or may not be possible, the latter symptom sometimes resulting from accumulation of blood-clot. *Peritonitis* rapidly supervenes if the peritoneal cavity is opened, and this may even arise by extension when the urine escapes into the perivesical cellular tissues, although this latter accident commonly only leads to abscess-formation.

TREATMENT.—*Abdominal section*, suture of the bladder, and a careful peritoneal toilet are indicated, with drainage if deemed requisite.

If reasonable doubt exists as to whether the peritoneum has or has not been opened, a suprapubic incision may be made, the prevesical space opened and drained after any vesical wound has been repaired. Advantage must be taken of the laparotomy or suprapubic wound to remove any ball, piece of bone, or clothing lodged in the bladder or elsewhere. *Late cystotomy* may be required to remove an undetected ball or pieces of bone which have primarily lodged in the bladder or found their way in by ulceration. Quiet, disinfection, and drainage of the wound-track, and prompt incisions to give egress to urine or pus, are requisite. Superficial wounds of the external genitals differ neither in danger nor treatment from similar ones produced by other traumatisms. Lodgement and even encapsulation of a ball have occurred. Marked laceration is the rule if the corpora cavernosa or glans penis are perforated :. the urethra is usually also opened.

PROGNOSIS.—Cicatricial deformities, urethral stricture, and fistulæ are not uncommon.

TREATMENT.—*Bleeding* must be arrested by ligature, suture, or com-

pression effected by firm bandaging of the organ after the introduction into the urethra of a metallic catheter. Antiseptic dressings are useful adjuncts. Any urethral wound must, when possible, be sutured, and the urine partially diverted by a retained catheter or completely by a perineal opening. When the whole organ has been shot away the corpus spongiosum must be dissected free and a perineal meatus established. Injuries of the *testes*, provided infection can be obviated, will usually do well, although atrophy or neuralgia are common sequelæ. If completely disorganized, castration should be done. Wounds of the *female genitals* are exceedingly rare, and often involve the peritoneal cavity. Wounds of the *pregnant uterus* usually produce death by abortion, shock, hemorrhage, or infectious peritonitis. *Fistulæ* giving exit to *menstrual fluid* have sometimes followed recovery after ball-wounds.

CHAPTER XXIV.

PROCESSES OF REPAIR.

By Charles B. Nancrede, M. D.

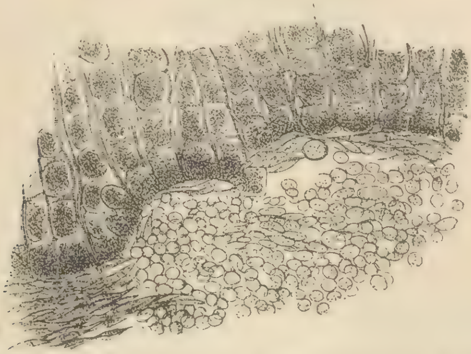
Repair is effected by the same processes in the hard and the soft, the vascular and the avascular tissues, the differences being temporary, non-essential, and chiefly dependent upon physical conditions. Thus, the lime salts render the bone so dense that until they are removed only a limited accumulation of leucocytes and, later, proliferated tissue-cells, can take place at the site of injury; yet from the outset the soft parts of the bone undergo the same changes, in kind, as does the least compact connective tissue.

Two forms of repair are usually described, but in reality there is but one, the second variety being at the outset only a modification of the first, caused by disturbing influences: when these cease to be operative the processes of repair tend to proceed as at their inception, any variations from the typical methods being accidental, not essential, parts of the process. In the *normal* method reparative processes commence from the moment the physical disturbance of the part ceases and the bleeding is checked. Here the minimum of reparative material is requisite, and the wound is said to *heal by the first intention*, by *simple adhesion*, or by *aseptic inflammation* (obsolete expression), because it is only possible in the absence of infection. Where infection occurs the reparative processes are interferred with and thwarted, reverting eventually to those seen in the absence of suppuration, but vast quantities of reparative materials are wasted, unnecessary tissue-destruction results, and the subsequent changes in the excessively developed germinal tissue often cause serious interference with function. Healing is here said to have taken place by *granulation* or by *the second intention*, but the end-processes are the same in both forms.

The following are the minute phenomena observed in the healing of an incised wound by *primary union*, or by *the first intention*. Hæmostasis is effected by thrombi occluding the vessels usually up to the first collateral branch. The blood, mingled with numerous leucocytes escaping from the divided lymphatics, provides elements for the formation of a coagulum (largely fibrinous), which extends for a short distance into the interstices of the tissues on either side, mechanically uniting the wound. Later the union becomes a vital one by the formation of fibre-cells and blood-vessels bridging the gap and developing into scar-tissue. The borders of the wound soon become crowded with wandering cells, which rapidly invade the fibrinous clot and any blood-coagulum filling up the recesses of the wound. By the close of the third day a mass of leucocytes, separated by a scanty intercellular substance and scattered remains of the clot, has replaced the coagulum. About the sixth day large epithelioid cells, resulting from proliferation of

the fixed connective-tissue cells and endothelial cells of the small vessels, appear. These are the *formative cells, the fibroblasts*, those capable of conversion into connective tissue. Most of the leucocytes serve as food for the new tissue-cells or wander back into the circulation by way of the lymphatics. Reinke believes that the lymphocytes which appear after proliferation of the fixed connective-tissue

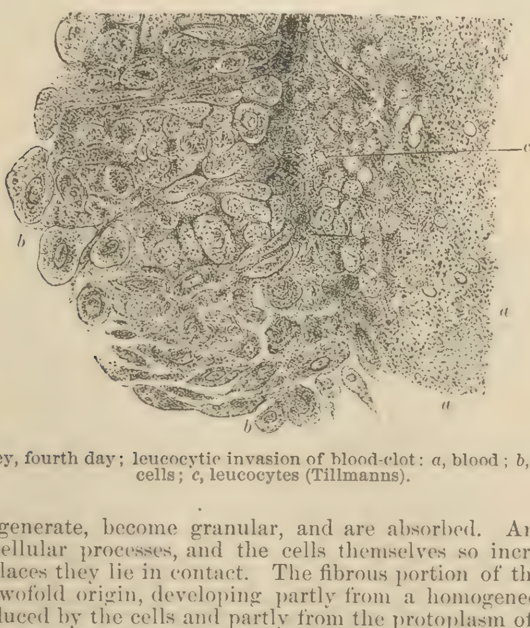
FIG. 132.



Phagocytosis of a piece of dead liver implanted in abdominal cavity of rabbit for twenty-four hours (Tillmanns).

cells has commenced are of different nature from those first appearing, and are capable of development into tissue, while Ribbert teaches that they aid in tissue-formation by providing the lymph-spaces with endothelium. The *fibroblasts*, at first round, enlarge and assume spindle or club shapes, or develop one or more processes, even becoming branched: giant cells also form, which, with some of the

FIG. 133.

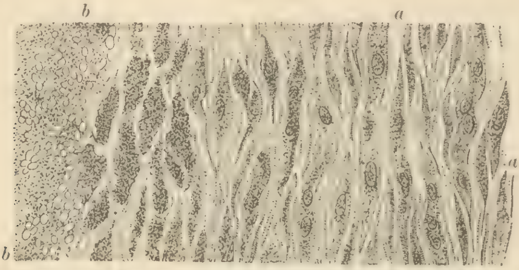


Wound of kidney, fourth day; leucocytic invasion of blood-clot: *a*, blood; *b*, connective-tissue cells; *c*, leucocytes (Tillmanns).

fibroblasts, degenerate, become granular, and are absorbed. Anastomoses form between the cellular processes, and the cells themselves so increase in numbers that in some places they lie in contact. The fibrous portion of the forming scar-tissue has a twofold origin, developing partly from a homogeneous intercellular substance produced by the cells and partly from the protoplasm of the cells. The fibrillation commences on one or both sides of the cells or at one end, or, again, in

one of the processes, the fibrils fusing with those of adjoining cells; the nuclei with some of the protoplasm form the fixed connective-tissue cells.

Fig. 134.

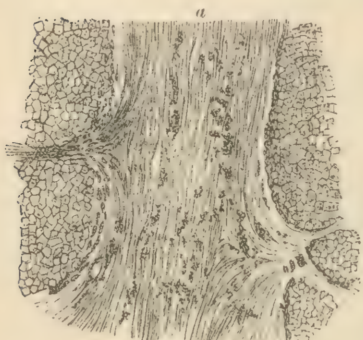


Cicatrizing wound of liver, tenth day: *a*, young cicatricial tissue; *b*, altered liver-tissue (Tillmanns).

Examination of a young cicatrix shows numerous elongated cells, which, becoming still further converted into fibres, diminish in size until little but fibres can be detected.

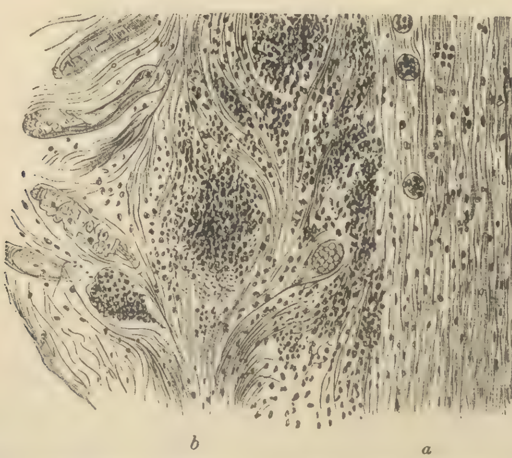
Rendering these changes possible is the nutriment supplied from the newly-formed vessels; moreover, some of the fibroblasts are derived from the cells of the intima of the new vessels. At the outset the cells receive nourishment from the plasma coming from relatively distant vessels in the surrounding tissues by way of the plasma-channels. The first steps in new vessel-formation consist in an accumulation of granular protoplasm [1] on the exterior of a pre-existing capillary loop which gradually forms a solid, nucleated filament. This may be simple or branched, and fuses with another vessel, with another bud from a neighboring capillary loop; or, again, the filament may arch back and become

Fig. 135.



Healed wound of liver, twenty-eighth day; blood-pigment in cicatrix still unabsorbed (Tillmanns).

Fig. 136.



Cicatrized defect in lung-tissue: *a*, cicatrix; *b*, infiltration with wandering cells (Tillmanns).

[1] By division of the endothelial cells at one spot.

connected with the vessel from which it sprang. The young connective-tissue cells (fibroblasts) near the vascular outgrowths arrange themselves alongside them or as

Fig. 137.

Formation of new capillaries by budding in liver, seventeen days after injury (Tillmanns).

bundles form solid continuations; again, they are said by some to form channels which later communicate with the lumen of some capillary: occasionally a proto-

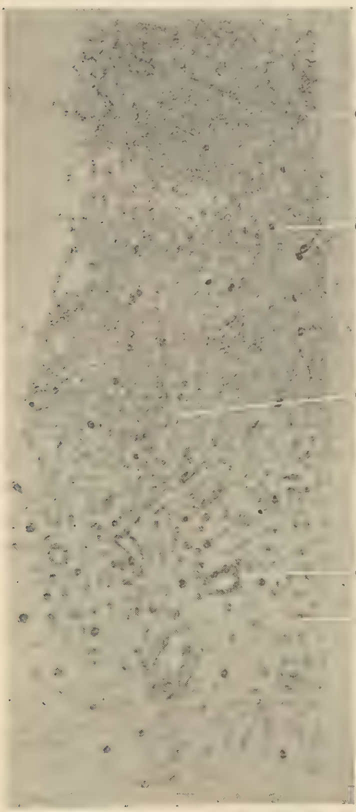
Fig. 138.

Formation of new vessels by budding: *a*, *b*, *c*, first stages; *d*, *f*, *g*, simple and branching buds: *e*, tubulation of a bud (Tillmanns).

plasmic filament will join a process of one of the branched formative cells. These solid protoplasmic processes liquefy in their centres, a lumen forming continuous

with that of the parent vessel. Sometimes the protoplasmic outgrowth is from the outset hollow, admitting blood, but even then it terminates by a filamentous prolongation, and develops further after one of the methods already described. At first the new capillaries have homogeneous walls. Later they display nuclei, and finally present the ordinary endothelial structure, their walls becoming strengthened by apposition of some of the neighboring tissue-cells. Most of the new vessels become obliterated by the condensation (contraction) of the newly-formed tissue, which accounts for the change of color in the scar from red to white. An aseptic wound with loss of substance may heal by "organization of blood-clot." This is merely an extension of the process by which the interstices of any aseptic wound are obliterated when filled with blood-clot. The coagulum serves as a scaffolding, being first invaded by leucocytes and then by germinal cells. These latter subsist upon the leucocytes, the cell-mass becomes vascularized, and the usual conversion into scar-tissue takes place. The gradual removal of blood-clot by the pressure of granulations springing from the surrounding tissues, which is sometimes spoken of as organization of a clot, is a different process, the clot here being a mechanical obstacle requiring removal, rather than an aid to healing.

Fig. 139.



Organization in blood-clot: *a*, fresh blood-clot; *b*, leucocyte; *c*, new capillary; *d*, cross-section of a capillary; *e*, young connective-tissue cells (Smith).

The so-called *filling up* of a wound by granulations is a misnomer. The organization of the deeper layers of the granulations into contracting scar-tissue draws down the wound-margins and lessens the superficial area. Microscopically, granulations consist superficially of numerous multi- and mononucleated leucocytes, with many delicate blood-vessels running more or less vertically to the surface. Deeper epithelioid cells abound, and still deeper spindle-cells arranged in bundles can be seen, in old wounds having become distinctly fibrous tissue, with the blood-vessels forming a horizontal network. The classical capillary loops capped with cells, which are said to account for the granular form of the granulations, do not exist, parallel vessels, ascending more or less vertically, as has just been said, being alone detected.

The foregoing statements include all the essential facts concerning the aseptic formation of granulations by which healing is effected in every tissue, although in certain highly specialized ones, as spinal nerves, regeneration of nerve-tubules takes place. Indeed, the end-processes are the same even when infection has occurred. Epithelial repair, covering the surface-defect, results from proliferation of the epithelium at the margins of the wound. Healing *by granulations* or by *the second intention* may pursue an aseptic or an infective course. The former occurs in wounds with loss of substance resulting from the original injury or from subsequent separation of dead tissue. Separation of devitalized tissue takes place without suppuration, the discharges are serous or lymph, cloudy from excess of leucocytes and young tissue-cells (not pus), and healing occurs with the minimum waste of material, dis-

PLATE XI.

Granulation Tissue; *a*, Subcutaneous Fat; *b*, Proliferation from Surrounding Skin; *c*, Granulation Layer, *a'*, Fat Cells; *a''*, Blood Vessel. (Klebs.)

charge, and formation of contractile scar-tissue: the minute processes are the same which will be mentioned as those terminating the healing of a suppurating wound. When infection of a wound occurs any mechanical bond of union is broken down; the scaffolding afforded by the uniting coagulum, by which the formative cells bridge the gap, is destroyed; many of the newly-formed cells perish, peptonizing ferments dissolving the intercellular cement and separating the cells from their source of nutriment, while other toxic bacterial products directly attack the vitality of the cells. The infiltrated surfaces of the wound are also destroyed to a varying extent by the same agencies, and a proliferation of cells far in excess of the needs for repair takes place, many of these being lost in the discharges, many not receiving enough pabulum to develop properly; but far too many survive to form dense cicatricial tissue. Where sloughing occurs the fragments of dead tissue provoke a lively proliferation of the cells of the neighboring living tissues, so that finally the dead and living parts are only held together by a mass of cells. These are soon disassociated by death of some and solution of the intercellular cement by bacterial products, when the sloughs separate, leaving usually far more granulation-tissue and consequent contracting scar than is produced by mere prolongation of suppuration without sloughing. The *end-processes* of this suppurative granulating process are the same as those already studied under aseptic union by the first intention. The same conversion of cells into fibres, the same method of vascularization, an identical but greater condensation (contraction) of the deeper layers of the healing granulating surface, reducing its superficial area, occur. (*Vide* Plate XI.)

Epidermization is effected by *proliferation of the epithelium* of the wound-margins, the remains of the Malpighian layer of the skin or the sebaceous and sweat-glands when the skin has escaped total destruction. In healing by either variety of second intention only a comparatively limited formation of new epithelium is requisite, because, as just seen, the defect to be covered is very materially lessened by contraction of the granulation-tissue. The last small area of granulations—and this is true of the end of any method of healing—may become covered by a dried crust of exudate, beneath which the epithelial cells form: when healing is completed the crust drops off. This is *healing by scabbing* or *under a scab*, and is a desirable method to attempt under appropriate circumstances. Two aseptic granulating surfaces, if maintained in contact, will often fuse together, healing then being said to occur by the *third intention* or *secondary adhesion*. Upon this fact depends the success of many cases of *secondary suturing*. The *vitality of skin-grafts* (not epidermic) of a severed nose or a finger-tip is maintained, according to Thiersch and Tillmanns, by direct communications formed between the vessels of the granulations and those of the graft or severed part through the medium of the intercellular plasma-channels. Later, all the phenomena described as pertaining to union by first intention (primary adhesion) occur. The transplanted part is passive until after the third day, when it commences to become vascularized. Despite the two or more days' interruption of direct blood-supply, only the epidermal layer, a portion of the rete Malpighii, and most of the vessels perish, the latter by atrophy and hyaline degeneration. In from

three to four days the epithelial cells of the sebaceous and glandular follicles proliferate and penetrate the mass of newly-formed cells, and in two weeks, according to Garré, the conversion of granulations into connective tissue is completed.

A few words as to repair in non-vascular tissues, as cornea and cartilage. In the former its anastomosing intercellular plasma-channels readily admit wandering cells coming from the vessels of the related vascular structures (sclera and conjunctiva), and later proliferation of the fixed cells and vascularization occur. The same remarks hold good for cartilage, except that the scar is alleged to remain fibrous for a long time if aseptic healing has occurred, while "if a severe inflammatory reaction takes place the cicatrix will rapidly become hyaline, like normal hyaline cartilage."

Regeneration of Tissues.—In only a few tissues does repair proceed beyond the formation of scar-tissue. Where regeneration is possible its perfection will be in proportion to the apposition effected and the asepsis secured. Surface epithelium and all connective-tissue structures, as fasciæ, bone, or tendons, can be completely regenerated.

Epidermis.—This, including the epithelium of the intestinal tract, is completely re-formed, the new cells being descendants of pre-existing epithelial cells found at the margin of the wound, or, after partial destruction of the skin, originating by division of the epithelium of various cutaneous glandular structures whose extremities lie in the deeper portions of the skin or actually in the cellular tissue beneath.

Skin.—Regeneration of the fibrous portion is complete, although the arrangement of the bundles is more irregular, and it is long before elastic tissue is developed in the scar, but the hair, sebaceous and sweat-follicles, with the true rete Malpighii, are not re-formed. Lymphatics are also absent, and an old scar is so much less vascular than normal skin, from obliteration of most of its vessels, that it is liable to break down from slight causes.

Fasciæ, Tendinous Sheaths, and Tendons.—Repair in these tissues amounts practically to regeneration. After division of a tendon the proximal end retracts, and the method of repair varies somewhat according to the presence or absence of blood-clot. In the rabbit, when but little blood is effused emigration of leucocytes occurs, followed in from two to three days by rapid proliferation of the cells of the sheath. Many of the cells of the tendon-stumps rapidly degenerate, but about the fourth or fifth day some take part in the formation of the granulation-tissue. The exudate extends some distance above and below the extremities of the softened, succulent, and newly-vascularized tendon.

According to Warren, when the sheath is filled with blood the clot is removed by ingrowths of vascular granulation-tissue springing from the sheath without primary infiltration with leucocytes; other observers deny this. The grayish cellular mass becomes pinker from vascularization (fifth day, Paget; tenth to fourteenth day, Warren), the new vessels in the granulations communicating with those of the tendon-ends. By the fifth day a spindle-shaped bond of union fills the gap. In the absence of any blood-clot the sheath collapses and adheres to the tendon-stumps, regeneration taking place by proliferation of the cells of the tendon-sheath and of the cut tendon. The new tissue gradually approximates that of normal tendon until microscopically no difference can be observed. The sheath is slightly adherent at the point of section.

Muscles.—*Muscular defects* are only repaired by *scar-tissue* forming from the connective tissue and endothelial elements. Near the cicatrix or after slight injuries and contusions regeneration is observed to a limited extent—according to one view, commencing by enlargement and proliferation of the muscular nuclei, resulting in the formation of large mono- and polynucleated cells, occupying the place of the destroyed fibres. These develop into spindle-cells lying side by side, which soon become longitudinally fibrillated and show commencing transverse striation during the third week. According to another view, granulation-tissue first forms among and around the necrosed muscle-fragments. The ends of the damaged muscle-cells break up into spindle-shaped fragments which undergo fatty degeneration preliminary to absorption. The nuclei of the living muscle-cells proliferate, forming bundles of muscular cells near the injured area which totally disappear by the third week. The disappearing fibre is replaced by a bundle of longitudinally striated fibres and spindle-cells formed by splitting up of the muscle-fibres and proliferation of the nuclei. Growth of muscle-fibres into the granulation-tissue and disappearing mass of muscular débris commences about the sixth day by small, multinucleated protoplasmic fibres springing from the stumps of non-degenerated fibres or from those longitudinally split. These outgrowths may be bifurcate, with club-shaped or fusiform extremities which contain many nuclei. Longitudinal striation occurs early, followed at the close of the second week by transverse striation. The new muscular filaments interlace, lateral budding being not uncommon. The fibres gradually increase in bulk and become striated transversely,

FIG. 140.

Obliteration of artery of dog four days after ligature: *m*, media; *t*, thrombus; *l*, ligature (Warren).

but many fail to develop and soon disappear by fatty degeneration, those which remain interlacing with others from the opposite side of the gap until the connective-tissue scar in very slight wounds may disappear.

Much of the interlacing disposition of the fibres is gradually replaced by a normal arrangement, but some irregularity always remains.

Blood-vessels.—Vascular repair depends upon the formation and so-called *organization of thrombi*—*i. e.* the formation of *vascular cicatrices*. Injury to or destruction of the endothelium and partial or complete arrest of the blood-current are requisite.

The exact rôle played by blood-plaques and white cells need not here occupy us, except that a vascular thrombus differs materially from a mere mass of clotted blood, being often entirely white.[1] Once started, unless only a portion of the circumference of the vessel is injured, the thrombus usually extends in time to the next collateral branch above and below. A mere rent or small wound may have a limited thrombus form, filling the gap, which may organize, leaving only a thickening: this is quite common in veins, but may also occur in arteries of any calibre.

Once formed, the thrombus may *organize*, may *calcify*, or may *soften*. The minute processes are as follows: The vascular wall first and the thrombus next become infiltrated with leucocytes, which seem to penetrate the latter by many routes, thus breaking it up into isolated masses. The endothelium proliferates where injured, and the thrombus gradually becomes replaced by formative cells thence derived, which penetrate along the tracks prepared by the previous invasion of leucocytes. Vascularization and subsequent development of the germinal tissue is effected, all traces of the thrombus being removed. The organization will be slower when the thrombus does not entirely occlude the vessel, because the formative cells can only enter through those portions in contact with the vessel-wall. One or more of the new vessels may persist or enlarge, restoring in a measure the continuity of the vascular lumen, but usually the occluded segment of vessel shrinks into a fibrous cord.[2]

A small wound of an artery may be repaired by blood-clot occluding the opening, hemorrhage being prevented by tense surrounding tissues. Here the thrombus extends through the gap in the wall and in the interior of the vessel around the wound, but does not entirely occlude the lumen. Granulation-tissue grows into and replaces the portion of thrombus occupying the vascular wound—a connective-tissue scar forming. Intravascular pressure causes gradual yielding of this scar, an aneurism forming, or perhaps the cicatrix suddenly ruptures, giving rise to an arterial hæmatoma. Repair after ligature of a vessel is essentially the same—viz. formation of protective thrombus, infiltration of vessel-wall and thrombus with leucocytes, proliferation of intimal and connective-tissue cells, substitution of the clot by these formative cells, vascularization of this germinal tissue, and conversion of the segment of vessel into a fibrous cord. Warren insists that at the site of ligature the vessel becomes converted into granulation-tissue, the vessel-ends separate, expand, and the granulations freely penetrate the thrombus, carrying in new vessels. Between the irregular masses of granulations spaces are left which after absorption of the clot form blood-spaces, opening on one side into the lumen of the vessel, on the other communicating with the capillaries of the granulation-tissue. As the clot and excess of exudate are absorbed a perfect cicatrix is formed, lined by intima, containing unstriped muscle, and externally composed of connective tissue. The persistence of a small central vessel communicating with the lumen above and the "capillaries surrounding the arterial stump" is also described as common. While Warren's observations stand alone with regard to the formation of a muscular scar, they are worthy of further investigation as explaining—if confirmed—why aneurismal dilatation so rarely results from the scar of a ligation in continuity.

[1] This does not, of course, preclude accretions of genuine clot, either ante- or post-mortem.

[2] Rokitansky's sinus-degeneration and other rare secondary changes must be studied elsewhere.

Nerves.—Under favorable circumstances repair is here complete.[1] The alleged immediate union of nerves with restoration of their conducting power, with no degeneration of the peripheral end occurring, *appears* to have been established clinically, but experiments upon animals negative this view, while anastomoses between nerves, *supplemental* or *vicarious sensibility*, and differences in the distribution of a given nerve probably explain the so-called *primary union*.[2] Degeneration of the whole of the distal with a portion of the proximal end is the rule, repair taking place chiefly by growth downward of embryonic fibres, originating from pre-existing fibrils: these penetrate the granulation-tissue by which the physical union of the trunk is effected. According to Howell and Huber's experiments upon the dog, in four days after section the myeline sheath becomes segmented and the axis-cylinder is fragmented in the peripheral portion of the nerve. By the seventh day active nuclear proliferation has begun in the neurilemma, with migration of the new cells, several often occupying one internodal space. During the next week the segmented myeline and fragmented axis-cylinder disappears by absorption, complete removal being effected in fourteen days. Next the nuclei acquire an investment of protoplasm, which increases until a single solid protoplasmic fibre with imbedded nuclei occupies the old sheath. "When union is made with the central end this is the rule, but if this does not take place, one or more fibres may arise within an old sheath by longitudinal cleavage." These amyelinic *embryonic fibres* later acquire a myeline sheath, the old sheath probably becoming part of the endoneural connective tissue. Return of function in the dog commences about the twenty-first day and is complete in eighty days.

From these experiments it also appears that nerve-impulses can be conveyed in the *embryonic-fibre* stage when they are united with normal fibres of the central end. Note carefully that the best results followed immediate suture (Howell and Huber), even an hour's delay producing a recognizable difference. It is probable, both from experiment and clinical observation, that when immediate suture is done, although complete degeneration of the peripheral end apparently occurs, yet regeneration is more rapid. Aseptic healing is more apt to be followed by a perfect result, the formation of much granulation-tissue as a sequence of suppuration presenting unfavorable conditions for penetration by the newly-formed nerve-fibres. The greater the extent of the distal portion, the longer will be the time requisite for cure. The same is true as to the time and perfection of result if a segment of nerve-trunk is destroyed. Where suture is not done regeneration is arrested at the "embryonic" stage, and a bulbous enlargement is apt to form composed chiefly of fibrous tissue: this is most likely to involve the proximal end. The preceding statements, although differing somewhat from previous teachings, probably correctly represent the present state of our knowledge upon this important subject, modern methods of research having invalidated some of the earlier observations.

Bone.—The union may be *immediate* or by *second intention*—*i. e.* by granulation, the bond being usually genuine osseous tissue. Examining a fracture of a long bone, considerable blood will be found effused from the ruptured medullary and Haversian vessels as well as from those of

[1] The peripheral end of one nerve (sensori-motor) has been united with the central end of another, with restoration of function.

[2] When these rare cases are opposed by the vast bulk of clinical and experimental results, demonstrating the apparent impossibility of this method of union, alleged cases of "immediate union" are to be viewed with grave doubt as to the accuracy of the observations.

the periosteum and contiguous soft parts which have been lacerated. Even in the rare event of the periosteum not having been torn, it is more or less stripped off the broken extremities. The injured tissues, infiltrated with blood, are soon invaded by leucocytes and exuded blood-plasma, and, fibrinous coagulation occurring, the extremities of the broken bone lie imbedded in a dense, ill-defined mass of firm cellular exudate involving periosteum, connective tissue, and possibly environing muscle. The blood entirely disappears by absorption in from fourteen to twenty-one days, when the firmer cellular exudate (callus) is seen to be a dense tissue, most abundant in and beneath the periosteum and extending between the ends of the fragments: in some parts the callus is cartilaginous. In from seven to fourteen days longer the soft callus ossifies, forming a spindle-shaped ferrule of porous bone (provided the fragments have not been much displaced). Meanwhile similar changes have also been taking place in the medullary tissues—viz. the blood-clot has been with the neighboring soft parts of the medulla infiltrated with leucocytes, the blood is next absorbed, the fat disappears as the connective and endothelial cells proliferate, and granulation-tissue forms from both bone-fragments, which soon fuses and develops into porous bone blocking the medullary canal. Much later the connective and vascular tissues occupying the Haversian canals in the compact bony tissue contiguous to the fracture proliferate, the lime salts gradually disappear, and the granulation-tissue thus formed is converted into bone, definitely uniting the fragments. When union has been finally completed the excess of external and internal callus is absorbed, the medullary canal is restored, and in time the site of the fracture may be hard to detect if the reduction has been perfect. When overlapping occurs, the open ends of the medullary canal become closed off by bone, and its lumen is usually only imperfectly restored by gradual conversion of the overlapping and fused portions of cortical bone into cancellous bone.

The following are the minute changes observed during the healing of bone. There is first *infiltration by leucocytes* of the effused blood, lacerated periosteum, muscles, etc. The *cells* of the soft parts of the bone, especially those of the deeper (osteogenetic) layer of the periosteum some little distance from the fracture, begin to *proliferate*, numerous angular and stellate cells (osteoblasts) appearing, which originate from the deep periosteal cells. Sooner or later similar changes take place in all the osseous soft parts—*i. e.* the periosteum, bone-cells, medullary tissue, and contents of the Haversian canals, *which are all continuous structures.*

Where the earthy salts and matrix of dense bone oppose a temporary physical obstruction to cell-proliferation, which can only be gradually removed, the soft-part changes occur more slowly. The new cells (osteoblasts), probably formed by division of the fixed connective tissue and endothelial cells of the bony soft parts as well as from the deeper periosteal cells, lie separated by a finely striated intercellular substance, each surrounded by a halo somewhat like that seen around cartilage-cells, the more highly differentiated portions forming interlacing trabeculæ: this is "osteoid tissue." Direct ossification may now take place, the cells growing smaller and some becoming branched, occupying spaces in the calcareous matrix—*i. e.* they are now bone-corpuscles. The lime salts commence to be deposited at numerous points in from ten to fourteen days, trabeculæ of true bone developing, while blood-vessels of new formation spring from those occupying

neighboring Haversian canals to ramify between the bone-plates: the new vessels run at right angles to those of the old bone.

Ossification usually starts in the angles formed between the separated periosteum and bone, and extending thence, the two buttresses meet and fuse at the middle of the spindle-shaped mass of provisional callus. *Bone callus*, as the tissue is now termed, is formed of a network of trabeculæ, the interstices of which are occupied by masses of young cells which have not yet ossified: the peripheral layer of these masses, however, are steadily being converted, layer by layer, into bone. Most of the hyaline cartilage sometimes found in callus disappears before the advancing ingrowths containing osteoblasts, but some is directly converted into bone by deposition of lime salts in the matrix, a portion of the cells remaining as bone-cells.

Similar changes occur in the medullary canal, the osteoid tissue commencing at the periphery of the canal and spreading thence concentrically until its occlusion is effected. Hyaline cartilage is rarely seen in this *internal callus*. Finally, the Haversian canals of the compact tissue of the ends of the fragments become choked with a round-celled infiltrate; the lime salts are dissolved and removed with the ground substance, large cancellous-like spaces thus resulting filled with young osteogenetic cells. The germinal tissue thus formed on the ends of the fragments with the contiguous portions of the cellular exudate composing the *internal* and *external callus* fuse, and union of the cortical bone takes place by *ossification* of this *definitive callus*.[1]

Healing of bone by the second intention—*i. e.* by *granulation*—takes place in open fractures where either loss of bone or death of bone occurs. In the first place, the periosteum having usually been destroyed over the osseous defect, the cells of all the soft tissues of the neighboring bone proliferate, forming the granulation-tissue, which, as the superficial parts close over and cicatrize, becomes converted into bone by one or more of the methods described. When necrosis occurs, at the borderline between the dead and living parts lively proliferation of the cells of the periosteum, medulla, and Haversian canals produces a mass of germinal tissue, some of the cells (osteoclasts) causing absorption of the bone-substance until the continuity of the dead and living bone is interrupted by a layer of cells. In suppurating wounds the bacterial peptonizing ferments effect the solution of the intercellular cement, thus detaching the dead fragment, but in aseptic wounds a similar result follows from a more gradual loss of vitality, disintegration, and solution of cells and cement. When the dead bone is removed the granulations go on to cicatrization—*i. e.* ossification.

[1] As the callus passes through a stage resembling the formation of fibrous tissue, and as the cartilage is often fibro-cartilage, it would seem that so-called *fibrous union* is a mere arrest of union at a certain stage of the process. If the disturbing causes can be removed in time, Nature may—as we know she often does—take up the process where it was left off and complete bony union. This explains the benefits accruing from rubbing of fragments together, subcutaneous drilling, and blistering over the fracture in cases of *delayed union.*

CHAPTER XXV.

TREATMENT OF WOUNDS: ANTISEPSIS AND ASEPSIS.

By Charles B. Nancrede, M. D.

In this last decade of the nineteenth century it would seem needless to do more than state the fact that modern surgery only became a possibility since Listerism—*i. e.* the principles of wound-treatment first enunciated by Lister—has become the rule in practice.

Although the injection of a number of irritant germ-free substances may initiate the formation of a puruloid fluid, this fact really has no bearing upon wound-treatment, since we are never confronted with such conditions clinically, and the resultant fluid is innocuous when injected into another animal. Again, the injection of culture-media or pus, in which the germs have been destroyed, merely produces the condition resulting from the action of living germs—viz. the presence of toxines and ptomaïnes, which are the active agents in the production of pus.

In practice, then, all pus and interference with normal wound-processes result from the presence of pathogenic organisms, for all germs are not harmful. To effect their exclusion or destruction it is requisite to understand the sources whence derived and the conditions favoring their development. They are present in the *air*, in *water*, in *dust*, and in the *soil*, and of course in *pathogenic wound-discharges.*

Surgically, those in the air will, if currents are prevented, gravitate and leave it completely or relatively free;[1] hence the necessity of avoiding draughts when operating or dressing wounds, long skirts worn by nurses, and sweeping, dusting, or moving hangings and furniture shortly previous to operations or dressings. Air in motion is never actually germ-free,[2] except above the snow-line on mountains, in the midst of extensive forests where much atmospheric moisture is present, and in mid-ocean, but under ordinary circumstances the number is too small to consider in a properly-kept operating-room, ward, or dwelling-house if draughts are avoided. Water, including rain-water, always contains germs, except sea-water some distance from inhabited coasts.

The soil and ordinary house-dust is a fruitful source. It is hardly necessary to say that the dust of hospital wards or private houses where suppurating cases have been treated teem with organisms; hence the advantages of such methods of construction and material as will least favor the lodgement of dust, which entangles and precipitates the germs. All exposed objects, then, may afford lodgement for germs, as instruments and dressings. Finally, the *surgeon's*, *attendant's*, and *patient's integument*, or, in the case of the latter, certain *mucous cavities or canals*,[3] are the chief source of pyogenic organisms. The foregoing embraces the really essential facts to be remembered in practice. Foul odors from sewers and privies contain

[1] The author has more than once exposed a Petri dish containing a culture-medium for one hour and a half in his operating-room, and been unable to detect a single colony after weeks in the incubator.

[2] Germs found in the air of ordinary dwellings are usually non-pathogenic moulds and fungi.

[3] The *expired* air is free.

few if any organisms, being damp, but the dried material from these sources may be carried by currents of air and will prove most harmful.

Some germs cannot live or develop when oxygen is present, others require the presence of air, but all varieties must have a proper temperature, moisture, and pabulum. Theoretically, pathogenic organisms should be best destroyed by the withdrawal of one of these essentials, but moisture is the only requisite that we can nearly absolutely control, although the amount of pabulum can be markedly minimized.

While it is true that if a wound is germ-free nature's reparative processes will pursue an uninterrupted course, it is also true that germs may be present and yet no harm ensue. The healthy blood and tissues destroy or remove germs, so that unless they are present in large numbers or the vitality of the tissues be lowered, no disturbance results and the germs promptly disappear. The more vascular tissues seem to possess the highest degree of immunity, as seen in wounds of the face. The absence or scarcity of pabulum produces similar results, as shown by Grawitz's experiments, where the introduction of sterilized fluid inducing a serous exudation determined a peritonitis after inoculation with pyogenic organisms, pabulum being present, because the peritoneum could not remove rapidly enough that which the germs fed upon and multiplied in. In the absence of the serous exudate relatively large quantities of pyogenic organisms could be introduced with impunity. Again, slight traumatisms of the peritoneum by lowering the vitality of the tissues at such points enabled the germs to gain a foothold, multiply, and initiate a spreading peritonitis.

These facts teach a twofold lesson: (1) that fluids that serve as germ-food should not be allowed to accumulate in wounds, and (2) that all unnecessary damage to the tissues must be avoided, because it diminishes their germ-inhibitory and destructive power.

To enable germs to produce their effects they must be either present in overwhelming numbers, or, more commonly, the resistance of the tissues being lowered, a moderate number multiply into a host. This explains the fact that an injury inflicted upon a person in health may produce little effect, but let the resisting powers of the tissues be lowered by previous disease at the point of injury, or let the vitality of all the body-cells be lowered by a serious disease, as glycosuria,[1] and extensive suppuration will often result from a trivial hurt. The general belief that atmospheric influences—cold, heat, moisture, etc.—can of themselves interfere with the healing of wounds is untenable, as is the alleged influence of individual predisposition to suppuration, or that cancer, tubercle, or syphilis causes failure in primary union. While it may be true that congestions, or local or general depression of vitality induced by such conditions, may render effective the implantation of a few germs which under other circumstances would be disposed of by the tissues, *if germs are absolutely excluded*, primarily or secondarily, wounds will pursue a similar course whether the weather be hot or cold, dry or damp—whether the patient be syphilitic or tubercular or absolutely free from any taint. Of course it is not contended that the healing processes will occupy the same time in all individuals, but that no *interruption* to these processes will occur if germs be excluded. (*Vide* also Chapter III.)

[1] Grape-sugar apparently favors the development of pyogenic organisms. See *Medico-chirurg. Soc. Trans.*, vols. lxxv. and lxxvi.

ASEPTIC SURGERY.

Two courses are open to the surgeon when operating or in the treatment of accidental wounds. He may remove, inhibit the growth of, or destroy all germs upon his own hands, those of his assistants, his instruments, sponges, the part to be operated upon, and in the dressings, nothing but that which is *aseptic—i. e.* germ-free—coming into contact with wounded surfaces. With proper precautions this germ-free condition persists, healing occurring with the minimum of disturbance. To this *method* the term *aseptic* is applied, the *ideal outcome of Lister's work.*

Owing to the impossibility of certainly excluding all germs or germs in harmful numbers, as in certain operations within the mouth, rectum, or in accidental wounds, measures must be adopted calculated to inhibit the growth of, or destroy when possible, all micro-organisms which have gained access to the wound, and to further prevent their subsequent multiplication in the dressings, whence secondary infection of the wound might result. Wound-treatment conducted according to these principles is termed *antiseptic* and is the original plan advocated by Lister. As many of the measures employed in this latter method are requisite preliminaries rendering possible aseptic operating, they must be considered.

Too much stress has been laid by some upon laboratory experiments and those upon the lower animals. It is indeed true that, lacking the knowledge thus gained, our present successes would be impossible or rest upon an insecure basis, yet these essential differences must never be lost sight of—viz. that in dealing with cultures of pathogenic micro-organisms thermic or chemical agents are afforded the freest possible access to the germs, whereas clinically much of their potency is lost by precipitation, dilution, or the mechanical impossibility of proper contact. The susceptibility to infection with pathogenic germs varies much among the different species of lower animals and in them and man, so that, while laboratory experiments suggest and warrant clinical experiments *on man*, they are not conclusive and sometimes prove disappointing.

Disinfection, or Sterilization (*Germ-destruction*), **and Disinfecting or Sterilizing Agents** (*Germ-destroying or Inhibiting Agents*).—Koch and his followers have demonstrated beyond cavil that *heat, and heat alone*, is universally germicidal, but while this is a fact, certain inherent difficulties confront us in practice. Much difference in results follows the method of employing heat. Thus contact with boiling water for one to five seconds will destroy the adult forms of any pathogenic micro-organisms, and the spores even of anthrax in two minutes. Steam may be used superheated—*i. e.* under pressure—or simple "live," actively generated, and freely-escaping steam. In this latter form it will destroy anthrax-spores in from ten to fifteen minutes. It must be remembered that *spores* are vastly more resistant than adult micro-organisms, and that all varieties of pathogenic micro-organisms succumb with ease as compared to the anthrax bacillus. A too common mistake is made in forgetting that while a limited period only is required for the action of any efficient degree of heat, *it must be that degree of heat applied directly to each spore or adult germ.* Hence even boiling water requires longer time to be germicidal, than in laboratory experiments, when employed for bulky, tightly-folded, or wrapped dressings, or when, as is often

true, germs are included in masses of coagulated pus, blood, or mechanical filth. This fact is of still more importance when steam is employed. All *dressing materials and instruments* must be, as far as possible, mechanically *cleansed* and then so arranged that the *steam* readily gains access to *all parts*, especially the interior of dressings.

It is folly to put tightly-folded, cold towels into a steam sterilizer for the minimum time employed in the laboratory to destroy pyogenic organisms, and then expect aseptic results. Hot air is the least efficient method of employing heat, because of the higher temperature and longer period of exposure requisite and its feeble power of penetration. Anthrax-spores, none of which survive after two minutes' contact with boiling water or fifteen minutes' exposure to "live" steam, require three hours' dry heat at 140° C. to produce the same effect, and much longer exposure when occupying the interior of dressings, folded clothing, etc.

Confusion of the essential differences between the germ-inhibiting action of chemical substances and between their action in the presence of living tissues and the wound-fluids is answerable for much of the past and some of the present theoretical and practical disbelief in asepsis and antisepsis. Nearly every agent we employ in the strength in which it actually reaches the germ is not germicidal, but does usually prevent the growth of micro-organisms to any harmful extent. Let the most thorough mechanical cleansing and chemical disinfection of the skin be employed, such as will presently be described, yet in most instances the chemical precipitation of the alleged germicide, say mercuric chloride, will demonstrate by culture-experiments that germs in harmful numbers are present, although incapable under ordinary circumstances of producing evil. It is not denied that when concentrated some of the chemicals ordinarily employed will destroy either at once or in a short time adult germs or even the resistent anthrax-spores, but in the strength possible safely to employ in a wound they inhibit only; hence the great importance of their mechanical removal and exclusion and conservation of tissue-resistance, because under certain circumstances chemical inhibition may fail.

Space will not be occupied with the daily lengthening list of substances which, in the laboratory, have proved to be germ-inhibitors or germicides, but only such will be mentioned as have proved most reliable clinically, can be resorted to in any emergency, or are peculiarly applicable to meet exceptional indications:[1]

	Marked Inhibition.	Complete Inhibition.
Mercuric chloride	1:1.600,000	1:300,000
Oil of mustard	1:333,000	1:33,000
Thymol	1:86,000	
Oil of turpentine	1:75,000	
Iodine	1:5,000	1:1000
Salicylic acid	1:3,300	1:1500
Eucalyptol	1:2,500	1:1251
Borax	1:2,000	1:700
Potas. permang.	1:1400	
Boracic acid	1:1250	1:800
Carbolic acid	1:1250	1:850
Quinine	1:830	1:625
Alcohol	1:100	1:12.5

Discrimination must be exercised in applying these facts demonstrated by Koch as true of anthrax-spores. No albumen or chemical substances interfered

[1] The reader is referred for details to Gerster's work on *Aseptic and Antiseptic Surgery*, and to the same surgeon's article in *Dennis's System of Surgery*. The author would here acknowledge his indebtedness to Dr. Gerster for much valuable information.

with the action of the agents. They were in absolute and prolonged contact with the organisms in a way impossible to imitate clinically. The equality, or rather slight superiority, of boracic over carbolic acid alone shows how rigidly experiment must be checked by clinical observation. Oily materials preventing contact with organisms or albumen forming inert albumenates are the chief foes of chemical germicides. In practice a proper choice of agents or a combination with other substances will often obviate these objections. Only such agents or procedures are commendable which are efficacious within a limited period, and which in themselves do not damage the tissues—*i. e.* reduce the tissue-resistance.

The last means of sterilization to be considered, although of the most importance so far as the surgeon's and assistant's hands and the field of operation are concerned, is the mechanical removal of *extraneous dirt, accumulated epithelium and germs*, and the *superficial epidermic layers* in which at least one pyogenic micro-organism has its normal habitat.[1] By the same means much of the oily matter abounding in the skin is removed, but when extra precautions are requisite certain substances especially adapted for the removal of fatty materials should also be employed.

Mechanical Sterilization.

The preparation of the surgeon's, assistant's, and nurse's hands will first be described. Sterilized water as hot as can be borne should be employed. This must, of course, be never cooled by the addition of any but cold sterilized water. In hospital practice this water is always to be removed from the vessel in which it is sterilized by heat at the time when about to be used. In private practice, after thorough boiling, the water, previously filtered when necessary, may be placed in sterilized vessels protected from atmospheric dust—*i. e.* that containing germs—by a sterilized towel. Special care must be exercised that the cup or dipper used to transfer the water from the vessel—oftentimes a wash-boiler or large tin dish—is always replaced in the boiling water to maintain its asepsis. The nail-brush, best made of vegetable fibre, must be always carefully rinsed after use and be sterilized by heat for each operation.[2] The heat employed may be live steam for fifteen to twenty minutes or boiling in water for five minutes. Although it is alleged that all soaps made by heat are sterile—indeed, that potash soap is an active germ-inhibitor in the proportion of 1 : 5000—yet it is the part of prudence to combine with the soft soap 5 per cent. hydronapthol or thymol to ensure that the soap itself is free from germs. After thoroughly rubbing in the hands and arms and under the nails abundance of soap, the nail-brush and hot water must be vigorously used, especially beneath and around the nails, for from two to five minutes. Next carefully clean the nails and around them with a nail-cleaner. Removal of all grease can now be effected by ether or by immersion in alcohol, or best by alcohol containing 5 per cent. of dilute acetic acid, which should be rinsed off thoroughly with sterilized water, removing the last traces of soap. Finally, the hands should be immersed—not merely dipped—in a 1 : 2000 mercuric solution, for not less than three—preferably five—minutes. Instead of corrosive-sublimate solution, ordinary mustard flour mixed in the hands into a thin paste with sterilized water,

[1] Staphylococcus epidermidis albus (Welch).

[2] And be placed in a carbolic acid solution until needed, as any soap left on the brush would interfere with the action of a bichloride solution.

used with gentle friction for two or three minutes and then removed with sterilized water, will prove a most successful germicide (Park).

The efficacy of the mercuric bath may be increased by scrubbing the hands and arms with the sterilized brush, previously freed from every trace of soap. This solution is to supplement the mechanical cleansing, which, it is again urged, must be that relied upon, and to inhibit the growth of any germs not removed and those normally resident in the epidermis. Were the fatal blunder not so common, it would be superfluous to mention that after the final cleansing described the hands must not be wiped on an ordinary towel, and should touch nothing but the disinfected instruments, towels, or field of operation. Should circumstances arise necessitating the use of a towel, a recently sterilized one or one wrung out of an antiseptic solution must be employed. Accidental contact with unsterilized objects, as clothing, the hair,[1] or beard of an assistant, demands, if slight, washing in a germicidal solution and rinsing this off with sterilized water. Fouling of the finger with buccal or nasal mucus, fæces, or pus necessitates a repetition of one or all of the original procedures: mustard flour is especially to be commended, promptly sterilizing and removing the odor of fæces better than anything the author is acquainted with.

Sterilization of the Field of Operation.—The same principles are applicable and almost identically the same measures are to be employed. When the patient's condition permits, a general warm bath should be taken, after which recently laundried clothing should be donned. Careful shaving should precede all operations. Next should follow prolonged but gentle scrubbing with nail-brush, hot water, and soft soap, especial attention being paid to such parts as the axilla, pubes, and umbilicus. All grease left must be removed by free bathing and rubbing with alcohol and acetic acid. Finally, a careful scrubbing with 1 : 2000 mercuric-chloride solution—or mustard flour used as already indicated—should be done, and the parts covered with a dressing wet with the same solution or one of 2½ per cent. carbolic acid, the latter being especially applicable where much oily matter is to be met with, as the scalp or axilla. This dressing should only be removed after anæsthesia has been induced, when the parts should be again cleansed with a germicidal solution, which then can be removed by free ablutions with sterilized water.

Certain additional precautions should be taken for brain-operations or those about the feet, hands, or involving opening of non-suppurating joints. In the former the sterilization just described might fail, because oily material normal to the scalp might prevent the germicidal solution proving effective; and in the latter, because of the accumulation of thickened epidermis harboring the germs, securing them against either mechanical removal or chemical destruction. The simplest adjuvant after shaving, alcohol, etc. is to apply, for a few hours, a thin layer of soft soap on absorbent cotton as a poultice, which must preferably be removed by free irrigation with weak carbolized or sterilized water, after which the permanent antiseptic dressing can be applied until the time for operation. Certain modifications become requisite when dealing with such cavities as the mouth, vagina, rectum, or where operative interference may possibly open into them. All of these, with the possible exception of the bladder, teem with organisms, and in none of them can strong chemical germicides be employed. Careful attention to the condition of the teeth, removal of all salivary calculus, extraction or filling of carious

[1] During operations about the head and face the hair must be covered with an aseptic or antiseptic towel carefully secured in place.

teeth, mouth-washes and sprays containing thymol, boric, or salicylic acids—one of the best being Listerine—with such treatment of any nasopharyngeal catarrh as circumstances will admit of, is the most desirable preparation for operations for cleft-palate, temporary or permanent resection of the jaws, ablation of the tongue, nasopharyngeal tumors, etc. The after-use of iodoform packing is also efficacious.

Vagina—Mechanical cleansing is here our mainstay. Abundance of soft soap on a vaginal mop made of sterilized cotton or gauze or a long soft jeweller's brush[1] should be employed to scrub the vagina, free irrigation with sterilized water being employed while doing this.

Follow this by douching with a 2.5 per cent. solution of carbolic acid or a 1 : 2000, or even 1 : 1000, mercuric solution, provided all the chemical be removed by free flushing with sterilized water and care to be taken to empty the vagina by firm pressure on the posterior commissure: permanganate of potassium or Thiersch's solution may be substituted. When vaginal hysterectomy is contemplated, these procedures had best be adopted some hours before operation and repeated upon the operating table. Dilatation of the cervical canal, curettage with the irrigating curette, disinfection by iodine, zinc-chloride solution, or the cautery, should also precede in most instances such operations. Curetting followed by milder but efficient disinfection must be employed before trachelorrhaphy.

Intestines and Rectum.—Thorough purgation and liquid diet must be employed, the former being sometimes properly secured in tight rectal strictures by a previous inguinal colotomy. Free and repeated lavage of the colon with sterilized water in the "knee-elbow" position is indicated shortly before operation.

After anæsthesia, when dealing with the rectum, a good-sized sponge secured by a strong thread should be passed well up the rectum, the field of operation be freely swabbed and flushed with Thiersch's solution. It may even be cautiously curetted and touched by the thermo-cautery in certain cases of ulcerating neoplasms. Possibly the internal exhibition of salol or thymol might aid in securing asepsis. Subsequent packing with iodoform gauze will aid in maintaining the asepsis. Temporary proximal and distal ligation or clamping of the intestines, walling off the healthy peritoneum by iodoform-gauze packing, stripping away by the fingers the intestinal contents before applying the clamps, mopping rapidly up all remaining fluid after incising the gut with pledgets of aseptic gauze, usually secure asepsis during intestinal operations. When the loop or loops of gut involved in the procedure can be placed entirely outside the belly, as is often the case, complete isolation from the general peritoneal cavity can be effectually secured by gauze packing and removal of the bowel-contents by flushing with sterilized salt solution. When healthy peritoneum is incised during operations for appendicitis or pus-tubes—*i. e.* when the opening is outside the adhesions[2]—careful packing with iodoform gauze should precede opening the pus-focus, all infected material should be removed as completely as possible, and, the soiled gauze having been cautiously removed, a clean packing should be introduced to remain until adhesions have shut off the general serous cavity.

The object in view when preparing the field of operation thus far has been the prevention of contamination of the deeper parts by germs derived from without or resident upon or in the integument or mucous membrane. While not, strictly considered, preparation of the field of operation, the special measures adapted to prevent infection by pus or secretions of the peritoneum, cerebral membranes, pleura, pericardium, and healthy bladder can best be considered in a general way here, referring the reader to the proper sections of this work for details.

[1] Gerster.

[2] The Trendelenburg posture must carefully be avoided when dealing with pus-foci, lest the remaining healthy portions of the peritoneal cavity become flooded with infectious material.

Cerebral Membranes.—No precautions other than those already mentioned are demanded except when operating for a known or suspected abscess. Then the site of the purulent collection must be surrounded with (aseptic) iodoform gauze before the abscess is opened to avoid a generalized lepto-meningitis, after which every particle of pus should be removed by careful irrigation with sterilized salt solution. If the pus be especially virulent, such slight risk as attends the employment of a weak bichloride solution may be safely encountered. Thiersch's solution may be employed with impunity if desired instead of the sterilized water.

Stomach.—When fecal vomiting exists from any cause or preceding gastrostomy, gastrectomy, gastro-enterostomy, gastrotomy, etc., gastric lavage should be done with Thiersch's solution or the normal salt solution, the latter being usually abundantly sufficient. Peritoneal infection must further be guarded against by suture of the stomach to the parietal peritoneum (gastrostomy) before incising the viscus, or after bringing the organ as far as possible into the parietal wound by careful walling off by packing with sterilized or iodoform gauze.

In gastrectomy and gastro-enterostomy clamps or temporary ligatures must be applied to the stomach (when possible in gastrectomy) and to a segment of intestine, carefully stripping this of all fæces, drawing the loop outside the abdomen when possible, packing gauze about it, and then, after opening, thoroughly but rapidly removing what little contents remain by pads of dry (sterilized) gauze, or, when outside the abdomen, by flushing with sterilized salt solution.

Liver, Gall-bladder, and Ducts.—Similar procedures are indicated when dealing with these structures.

Accidental Operative Wounds of the Pleura, Pericardium, and Peritoneum.—If the conditions are favorable, immediate suture is preferable, but if subsequent manipulations might open again the wound, temporary gauze packing must be done. This may be removed and the wound sutured at the close of the operation, or a clean packing[1] allowed to remain to induce limiting adhesions, aid in disinfection, and serve as a drain if the serous membrane has certainly or probably been infected during the operation.

Bladder.—Although the introduction of a few pathogenic germs into a healthy organ may prove harmless, owing to their prompt removal with the urine, they may produce the most disastrous results. An already diseased viscus containing a stone or tumor is what the surgeon usually has to deal with, and here the introduction of streptococci or staphylococci—the usual causes of cystitis—is certain to give rise to trouble. As operations involving the bladder demand in nearly every instance the introduction of instruments *per urethram*, an antecedent aseptic condition of this canal must be secured. Normally, the urethra is alleged to harbor many germs which if carried into the bladder can originate a cystitis. Most careful lavage of the urethra must be performed, when possible, by a retro-acting deep urethral catheter, using sterilized salt, boro-salicylic, or bichloride solution according to the condition present.

If urethritis be present, any introduction of instruments is to be deprecated, and when unavoidable a most careful employment of the measures is indicated.

[1] The so-called Mikulicz drain is the best way to employ packing in such cases.

Urethral first, and then vesical, lavage must precede all operations upon the bladder except where impassable structure exists. As soon as any such impediment is overcome most thorough washing out of the bladder and urethra should follow or be used during the operation—first with an antiseptic solution, then abundance of sterilized salt solution. The internal use of salol, quinine, or boracic acid for a few days previous to operation often markedly changes the character of unhealthy urine, and is imperative when the upper urinary passages or kidneys are involved in the infective process. Salol must not be exhibited for a lengthened period, owing to its noxious action upon the kidneys.

Antiseptic Surgery.

This aims to *remove*, *destroy*, or *neutralize* the noxious effects of germs which have gained lodgement in the tissues. Heat, when applicable in the form of the *cautery*, is most efficacious, directly destroying the germs and the tissues in which they reside, converting these into an aseptic eschar, which must separate by processes which commonly leave a layer of healthy granulations usually competent to bar the further ingress of germs. *Chancroids*, *lupus*, *tubercular* and such spreading processes as *hospital gangrene*, are amenable to this treatment. Except when employed as potential cauteries, chemical substances cannot be used in sufficient concentration to destroy all germ-life in an infective process. Hospital gangrene and some few analogous conditions have, it is true, been successfully combated with pure bromine, carbolic, and chromic and fuming nitric acid, and strong solutions of chloride of zinc, but these must destroy, as the hot iron does, all the infected tissues, otherwise after a period of quiescence the disease will break out anew. Many of these and other substances employed, as *corrosive-sublimate paste*, are poisonous if applied to large areas. Most usually, disinfection by lotions is limited to the superficial portions of the infected area. *Removal of all infected tissues* by excision—when limited by curetting or dissection with knife or scissors—is most efficacious, as in some carbuncles or in anthrax. When complete mechanical removal is impossible partial excision may be supplemented by the actual cautery, as is often done in anthrax. *Incisions by relieving tension*, giving exit to discharges and sloughs, mechanically remove many germs and toxines, besides rendering possible the access of germ-inhibitory substances. *Irrigation* with a powerful stream is an important mechanical adjuvant to incision, but distention of the cavity must never be permitted, two tubes being employed or a counter-incision made. Rough handling must also be avoided, as calculated to rupture granulations or the tissues and thus open up new avenues for infection. An exception to this rule is often presented by certain ischio-rectal abscesses, where the cavity should be made a simple one by breaking down the irregular partitions.

Peroxide of hydrogen is useful to disinfect irregular cavities when not too large. *Tubes* are preferable to packing in all cases where it is not certain that all infection has been removed, because the solid portions of pus cannot be removed by capillary action; but packing to secure the prolonged contact of iodoform with sloughs or infected tissues, because of its germ-inhibitory and toxine-destroying property and to prevent re-infection, is often useful and may be combined with tube-drainage. *When the discharge becomes serous* and small in amount, *drainage can be dispensed with*, but gradual shortening of the tubes and lessening of the

quantity of packing at each dressing must precede this until the cavity becomes nearly effaced.

At each dressing any sloughs remaining must be removed, but frequent irrigation is only necessary for anfractuous cavities, where efficient drainage is anatomically impossible. Sometimes continuous irrigation or the continuous bath is indicated, as in extensive cellulitis of an extremity, when only non-toxic chemicals, as boric or salicylic acids or aluminum acetate, should be employed, lest systemic poison occur. The powerful aid of *position* to favor drainage and relieve congestion must be invoked. When packing a wound each recess should have its own piece of gauze, one end being left protruding, and careful count be kept of the number of pieces. When re-dressing replace each piece with a clean one as the soiled one is withdrawn, although this rule often cannot be followed. Moist antiseptic dressings are indicated until only serum is secreted, because drying of discharges upon the dressings would interfere with drainage; moreover, the wound-discharges, being septic, would tend to infect the wound if the germs were permitted to multiply unchecked. When the wound becomes aseptic a dry aseptic dressing may be applied.

Drainage.—Many aseptic operations require no drainage. Increasing experience and improved technique lead each surgeon gradually to discard it. In some form it becomes necessary—(1) *when much bloody serum will be poured out;* (2) *where cavities must be left;* (3) *where perfect asepsis or its maintenance is doubtful;* (4) *where infection has occurred.*

Drainage may be *direct—i. e.* where discharges are removed by tubes etc.; or, *indirect—i. e.* by leaving a part or the whole of a wound open; packing or employing secondary suture; by buried sutures, compresses, bandages, etc., so disposed as to leave no cavities in which fluids can collect.

Direct drainage is *tubular* or *capillary.* Well-annealed glass tubes with lateral openings are best when of the proper length, because non-collapsible and readily sterilized by boiling. Rubber tubes are more commonly employed because capable of being used of any length.

The tubing selected should be sufficiently rigid to prevent kinking. Boiling for five minutes in soda solution or placing them in the steam sterilizer for twenty minutes will sterilize them. They should be cut in lengths and stored in a 5 per cent. carbolic solution. Tubes should reach well into the cavity, but not impinge upon its base, and with this end in view must be cut flush with the skin, being secured *in situ* by a sterilized safety-pin thrust through the tube or by a special stitch through one margin of the wound, including the tube. No tube should rest upon or against a nerve or blood-vessel.

Capillary drainage is only adapted to the removal of blood or serum, and must never be used for pus. A *strip of gauze* protruding from an angle of a wound is sometimes employed. *Sterilized horsehair* or fine catgut is the usual material. Certain precautions must be observed.

Secure the middle of a bundle of from twenty to forty strands of hair or gut to the deepest portion of the wound by a stitch of catgut. If buried sutures are employed, bring four strands between each two stitches. Between each pair of skin-sutures the same disposition is to be made. The threads must be carefully smoothed out, so as to be parallel and in contact, their ends cut off squarely, and a piece of protective laid over all. This must extend some distance beyond the ends of every drain, otherwise they become agglutinated by desiccation and cease to drain. Neglect of these precautions invariably leads to failure. Catgut is absorbed, but horsehair must be withdrawn at the end of forty-eight to seventy-two hours, either entirely or a few hairs at each dressing.

Sterilization of Instruments, Ligatures, Sponges, and Dressings.

Instruments.—All instruments should be entirely metallic, with smooth plane or simply curved surfaces. If complex, they must be readily separable into their component parts to permit mechanical cleansing. Wooden or ivory handles are damaged by heat, and from the inequalities of their surfaces are hard to cleanse mechanically; still, they can be sterilized by the exercise of care. Aluminum being attacked by alkaline fluids is therefore undesirable. Too much stress has been laid upon the receptacles in which instruments are stored. It is demanded that they be constructed of enamelled iron and glass tightly closing to exclude dust. Even the pocket-case must be metallic or made of canvas, so that it can be frequently sterilized.[1] While desirable, these are unnecessary refinements, deluding to those not thoroughly versed in aseptic principles, because the asepsis is only relative and ignored by the expert, because he never trusts to such inadequate precautions, *but specially sterilizes his instruments for each operation.*[2]

Fig. 141.

Briggs's sterilizer.

The importance of mechanical cleansing by soap, hot water, and friction is demonstrated by recent experiments where smooth, metallic, or even gum instruments have been made germ-free by brisk rubbing first with a wet (sterilized) cloth, then for a few minutes with a dry sterilized towel. All instruments after use should be mechanically cleansed and kept polished.

Chemical disinfection of instruments has long been abandoned in favor of heat, except to meet special indications, because of its unreliability and the injurious effects exerted upon instruments, destroying the cutting edge and polish and interfering with the smoothness of working if complicated. Dry heat, being tedious in its application, injurious to temper unless skilfully employed, and requiring cumbersome apparatus, is rarely employed. Many surgeons prefer in hospital work "live" steam, the water from which it is (Fig.

[1] Unquestionably, if instruments are sterilized for operation *at the surgeon's office*, an aseptic case is requisite, but few adopt this plan.

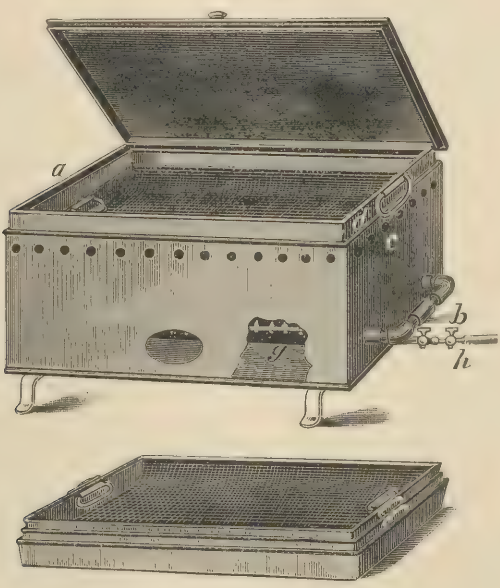
[2] The author has more than once taken a polished steel instrument off a velvet-covered shelf in a general hospital, and has been unable to detect germs by culture-methods.

141) generated being charged with 1 per cent. of washing soda. This prevents rusting and adds to the germicidal powers. From five to ten minutes' exposure will kill any pyogenic organisms, since twelve minutes will destroy anthrax-spores. More than ten minutes may be advantageously employed to ensure the best results.

In private practice boiling water containing 1 per cent. of soda is more rapid and convenient than steam, any vessel large enough to contain the instruments serving to boil them in. Pure cultures of the pyogenic organisms will succumb in the boiling soda solution in from two to three seconds, and anthrax-spores in two minutes.

In hospital work Schimmelbusch's apparatus is probably the best, each set of instruments being placed in a separate wire tray, which is immersed in the boiling water for five minutes, taken out, drained, and the instruments placed in cooled sterilized salt solution or laid upon and covered with sterilized towels until needed. Any instrument accidentally infected during an operation can be sterilized by dipping in the boiling solution for a few seconds.

Fig. 142.



Schimmelbusch's instrument-boiler.

While the *sterilization of metallic bougies* and *catheters* by heat or boiling presents no difficulties, it is far otherwise with the *elastic* (English), the *soft* (French), and the *pure rubber* (Nélaton) instruments. If oily substances be used as lubricants for these soft instruments, they should be soaked for a short time in warm (not hot) solution of washing soda previous to sterilization. If glycerin is employed, simple sterilized water will suffice.

The Nélaton catheter, according to Gerster, may be sterilized by immersion for fifteen minutes in the soda solution at a temperature "just below the boiling-point." How this is to be maintained or ascertained in practice is not described, and if done often will assuredly render them dangerously brittle. The asepticity thus gained must be maintained by storing them (suspended) in a tall jar filled

with 5 per cent. carbolic-acid solution or 1 : 2000 bichloride. They must be rinsed in sterilized water before using, and carefully cleansed before replacing in the jar. If glycerin is not employed as the lubricant, all grease is to be removed by a soda solution. The other varieties of catheters can be sterilized by a short immersion in strong solutions (20 per cent.) carbolic acid or 1 : 500 mercuric chloride, afterward removing every trace of these chemicals by sterilized water. Storing in antiseptic solutions seriously damages these instruments, and should be avoided. Mechanical cleansing after use must be carefully done.[1] Farka's instrument for passing steam through these catheters is efficient, but is often not accessible. Lubricants, as vaseline, oil, or glycerin, must be first sterilized by heat. The instruments should never be dipped into the receptacle, but a sufficiency be dropped into the hand and transferred to the instrument, making all the manipulation with sterilized hands. Montgomery has suggested sterilizing catheters by steam, placing them in strong glass tubes, longer than the catheters, the ends of the tube being plugged with cotton. In these tubes the catheters are kept, one in each, until wanted for use. After using and cleansing they are again sterilized in the same way.

Sterilization of Accessory Apparatus and Instruments.—By these are meant *inhalers, mouth-gags, tongue-forceps, throat-mops or sponges, hypodermic syringes, and hypodermic solutions.* As the so-called Esmarch inhaler or its modification for chloroform, Allis's for ether, or the extemporized towel cone, have nearly superseded all others in this country, their disinfection will be now considered. Where the flannel or cottonet is sewn upon the metallic frame the whole apparatus must be boiled or steamed and dried, a fresh one being required for each patient. If the Schimmelbusch type is used, the metallic portions must be boiled for a few minutes and a fresh piece of recently laundried flannel employed for each patient. The same remarks apply to the Allis inhaler, so that in hospital practice several of these must be on hand ready sterilized. A fresh extemporaneous cone made of sterilized towels (recently laundried) must be used for each patient. Mouth-gag, forceps, and throat-sponges must also be sterilized, and for similar reasons—viz. the *danger of conveying syphilis* from patient to patient or the introduction into the oral passages of pathogenic germs. Fatal results from *sepsis, tetanus,* and *malignant œdema* having followed *hypodermic injections,* and tedious convalescences from the effects of dirty needles have so often occurred that asepsis is essential. No *solution* should ever be employed which has not been subjected to *boiling*—best just previous to use. The hypodermic pellet or drug, the needle, and the water can all easily be boiled for a few minutes in a spoon over a gas-jet, lamp, or even a wax or ordinary match. The syringe itself should be occasionally filled with warm water, placed in the same, and carefully boiled. This is recommended because, while repeated rinsing out with boiling water has been proved to be efficient, and ought to be employed before using, yet additional precautions should be adopted where such instruments are in constant use. *Aspirating apparatus* when the direct method is used must be disinfected in a similar manner; but the indirect method—*i. e.* where a reservoir is used—is to be preferred, as the syringe never becomes contaminated. Brisk friction of the skin for a minute with alcohol, followed by a germicidal solution, must precede the introduction of the needle.

As vulcanite syringes can only be cleansed by repeated filling with and emptying of hot water, wherever possible gravity should be employed instead of such

[1] See p. 25 or Schimmelbusch, *Anleitung Zur asept. Wundbehandlung,* p. 192.

instruments, using fountain syringes or irrigators. The receptacles, tubes, and points of these can all be readily disinfected. In hospital practice a glass point for each patient is desirable, to be cleansed after and disinfected before using. These precautions should extend to the enema-syringes or irrigators, to the vaginal douche-points and reservoirs, because disastrous results have followed the neglect of these apparently superfluous precautions. Rubber bags and tubing should be immersed in strong germicidal solutions, afterward removing all traces of these with sterilized water.

Sterilization of Dressings.

Materials.—Cheese-cloth, butter-cloth, cotton, jute, moss, pine-sawdust, peat, ashes, asbestos-wool, sand, and innumerable absorbent substances have been employed, but cheese-cloth, butter-cloth, cotton, sawdust, and moss are those which are most available. As we have seen, moisture is essential to germ-life, therefore an *ideal dressing* must (1) *desiccate the wound—i. e.* promptly abstract the wound-secretions, absorb them, and permit rapid evaporation of the fluid portions; (2) they must be *aseptic*, and (3) *capable of maintaining this by preventing multiplication of germs.* The first requisite is secured by removing all oily material from the cheese-cloth, cotton, or textile fabric employed by boiling for fifteen to thirty minutes in a solution containing 5 per cent. of washing soda, rinsing out in cold water, and drying. Butter-cloth does not require this treatment. Sawdust, oakum, and all kinds of gauze or moss must be sterilized by dry or moist heat or by immersion in a germicidal fluid if moist dressings are to be employed. If this is not convenient, they can be sterilized and remain in boxes, such as recommended by Schimmelbusch, or in sterilized fruit-jars.[1]

Maintenance of the aseptic state of the dressings of an aseptic operation is secured by their arrangement in such a manner as will favor the drying of wound-secretions as soon as possible after their absorption. Exposure for thirty minutes to steam in any steam sterilizer, such as that of Schimmelbusch or Arnold, which fulfils the indications of previous warming of the dressings and generation of steam under some pressure will secure dry, efficiently sterilized dressings.

Schimmelbusch's and Willy Meyer's apparatus provides for sterilization of instruments by boiling in the soda solution, and of the dressings, operating gowns, etc. by the escaping steam. The former's boxes are metallic, with numerous lateral openings closed by revolving the circular collars. The dressings, operating gowns, and towels are placed in one loosely folded; it is closed and put in the sterilizer with the fenestra opened. After half an hour it can be removed and the collar rotated so as to close the opening, when the contents will remain aseptic. In the absence of such boxes the dressings, etc. must be carefully placed in sterilized towels, the coverings only being removed at the time of using. While portable sterilizers of all these patterns are convenient, boiling of dressings, aprons, and towels for fifteen minutes in the soda solution suffices for private practice. If dry dressings are imperative, enveloping them in a sterilized towel, thorough wringing, and drying in a hot oven will do admirably.

Fig. 143.

Schimmelbusch's dressing-box.

[1] No reliance should be placed in the commercial antiseptic gauzes or ligature materials.

Chemical sterilization is best effected by corrosive sublimate—when not contraindicated—employed in the strength of 1 : 2000. The gauze (if possible previously sterilized by heat), cut and folded, should be steeped in the solution, not be merely dipped in, and when applied wrung as dry as possible.

Sponges.—These may be marine, but those made of knitting wool, absorbent cotton, or wood-wool loosely gathered up and secured within a double layer of absorbent gauze, or pads of sterilized gauze so folded as to prevent ravellings being left in the wound, are preferable for most purposes, because both cheap and sterilizable by heat.

Sterilization of Marine Sponges.—Beat with stick or in large mortar to free from sand; place for twenty-four hours in potassium-permanganate solution 1 : 500; transfer to 1 per cent. sodium-subsulphate solution containing 8 per cent. by volume of hydrochloric acid (C. P.) for fifteen minutes; remove all traces of this by repeated rinsing in sterilized water and store in 5 per cent. watery solution of carbolic acid; when used they must be freed of the carbolic acid by rinsing in sterilized water.[1]

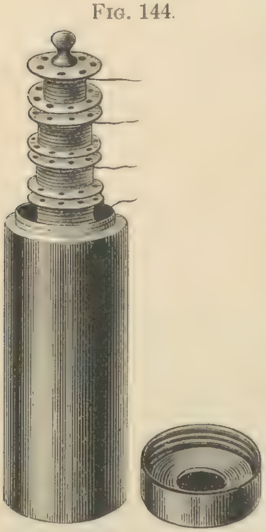
Sterilization by heat can be done thus: free from sand; wash and then macerate in water seven to fourteen days; wash in warm water and place in a muslin bag; immerse for thirty minutes in 1 per cent. soda solution removed from the fire when actively boiling;[2] rinse in cold sterilized water while yet in the bag; store in sublimate or carbolic-acid solution.[3]

All forms of gauze sponges and pads should be boiled for fifteen minutes in the 1 per cent. soda solution or subjected to the action of steam for thirty minutes.

Sterilization of Ligature and Suture Materials.

Heat is again superior to chemicals, and can be employed in a number of ways: usually both methods are combined. For metallic wire, horsehair, silkworm gut, silk or flax thread, after loosely rolling on glass spools or rods, boil for thirty minutes in a soda solution and store in a 5 per cent. carbolic-acid or a 1 : 3000 corrosive-sublimate solution or in previously boiled absolute alcohol.

Fig. 144.



Aseptic portable ligature-box.

The theoretical objection to the employment of any chemical substance in sterilizing ligature materials because damaging the tissues, thus lowering their resistance and favoring infection, can usually be ignored in practice, the amount of the drug in each ligature being infinitesimal; still, if this objection is considered a valid one, boiling immediately before use in the soda solution or storage in previously boiled alcohol will meet all objections.

Catgut or Other Animal Ligatures.—Roll loosely on glass rods or spools; place in large jar of absolute alcohol with screw cap or in preserve-jar, with cover, in either case only moderately tightly closed to prevent unnecessary waste of alcohol; place in water-bath and subject to the boiling temperature for two hours; screw cover down firmly and keep stored.

[1] Frisch, from Gerster, p. 699, *Dennis's Syst. Surgery*, vol. i.

[2] The temperature will not fall below 80° C. until all germs have been destroyed, anthrax bacilli requiring only between 80° and 90° C. for from ten to twelve minutes.

[3] Schimmelbusch.

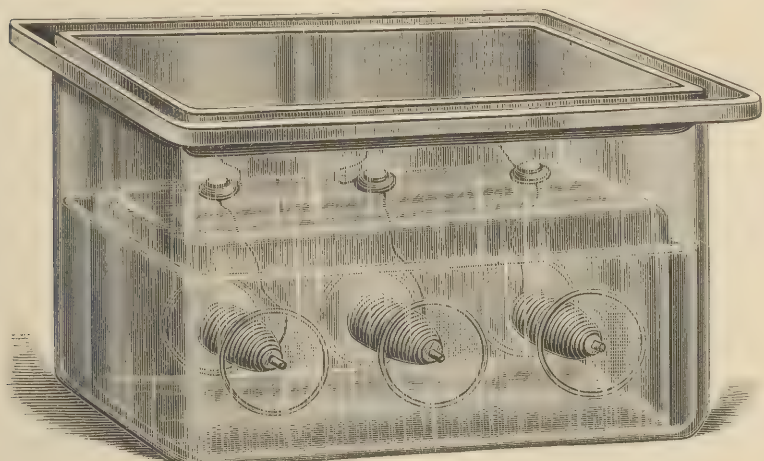
Brunner's Method.—Subject the gut, immersed in xylene in a closed vessel, to steam (100° C.) for three hours; wash in alcohol and store in alcoholic solution of bichloride 1 : 2000.

Schimmelbusch's and Bergmann's Method.—Place receptacle and glass spools in a steam sterilizer for forty-five minutes or boil in soda solution; then roll the catgut on spools and soak in ether for twenty-four hours to remove grease; pour off ether and substitute a solution of corrosive sublimate parts 10, absolute alcohol parts 800, distilled water 200 parts; replace this in twenty-four hours, because it will become turbid; allow the gut to remain for seventy-two hours; store in the same solution, or, if stiff gut is desired, in absolute alcohol (boiled); if moderately stiff, add 20 per cent. of glycerin to the alcohol (both boiled).

Chromicized Catgut.—This does not disappear so rapidly in the tissues. Macewen places the commercial gut for two months in glycerin 20 parts, aqueous solution of chromic acid (20 per cent.) 1 part; it is then washed and stored in a 20 per cent. solution of carbolic acid in glycerin.

Numerous other methods have been employed,[1] but those given are reliable and possible for any surgeon to carry out. The illustrations will serve without words to describe the more convenient but not essential receptacles, portable and stationary, for the storage of ligature material. It is advisable to subject the receptacles and their contents to the action of steam.

FIG. 145.



Glass jar for wet catgut or silk.

Aseptic Solutions; Chemical Germicides; Antiseptic Ointments.—*Sterilized Salt Solution.*—This is a 6 per mille solution of sodium chloride prepared by boiling for fifteen minutes.

Corrosive Sublimate.—As most waters contain lime, which decomposes this drug, acetic, tartaric, citric, or some mineral acid, as hydrochloric, or table salt must be added. The vegetable acids and table salt may be added in the same quantities as the mercurial salt, the hydrochloric so as to render the solution faintly acid to litmus. Moreover, these acids prevent the formation of an inert albuminate when used in the wound.

[1] H. Kelly subjects the gut, suspended in a bottle, to 80° C. for two hours to get rid of moisture. It is then boiled for one hour in cumol placed in a sand-bath (160° to 170° C.). It is then placed in chemically pure benzine (which is sterile), where it may remain stored, or it is transferred to sterilized absolute alcohol. The author has used this method with entire satisfaction.

The strength of mercuric solutions are for irrigation 1 : 150,000 to 1 : 5000; 1 : 2000 to 1 : 1000 for infected wounds, disinfecting hands, and the field of operation; for bone-cavities, possibly as strong as 1 : 500.

Where strong solutions are employed, or even weak ones, it is good practice to secure the removal of all traces of mercury from the wound by flushing with sterilized water. Patients must be closely watched, lest salivation or gastro-intestinal irritation result, shown by abdominal pain and frequent mucous or bloody stools. Locally, *dermatitis and vesication* may result. *Carbolic acid* is employed in 1, 2, and 5 per cent. solutions, the weaker for irrigation and instruments, the stronger for septic wounds. It is readily absorbed, requiring watching, especially in children. An *olive-green tint of the urine* is usually an early symptom of *poisoning*, which soon may be followed by cerebral and circulatory symptoms, as headache, vertigo, coma, eclampsia, vomiting, feeble heart-action, suppression of urine and entorrhagia, in the worst cases terminating fatally. Locally it is irritant, often causing eczema, while the long application of strong solutions has often determined dry gangrene of the fingers or toes.

Salicylic acid, best used as Thiersch's solution (acid, sal. parts 2, acid. boric parts 12, aquæ 1000), is a weak, non-poisonous germicide. It may also be used in ointment form. Acetate of aluminum in 1 per cent. solution is effective, safe, and specially adapted for irritable skins.

Potassium permanganate, 1 : 500 to 1 : 2000, weak but safe, is useful in the mouth, urethra, and bladder. *Peroxide of hydrogen*, a powerful germicide, is specially useful for foul, sloughing wounds. The fifteen-volume solution may be used pure or diluted once, twice, or thrice, Salivation has been attributed to its free use.

Chloride of zinc, 5 to 20 grains to the ounce, is most efficient.

Iodoform is invaluable, acting by virtue of the iodine set free in the presence of infected living tissues, neutralizing the ptomaïnes, etc. and inhibiting germ-growth. It is poisonous, especially to the old and anæmic, and often produces dermatitis. As iodoform gauze it is the chief reliance in the oral, rectal, vaginal, and vesical cavities when secondary suture is to be employed, as a protective dam in various conditions, and as packing to arrest oozing after certain abdominal operations. Slight poisoning is shown by headache, mental depression, anorexia, or nausea and vomiting; more severe cases exhibit insomnia, have a rapid pulse, high temperature, delirium, sometimes maniacal, coma, and convulsions: iodine can be detected in the urine. These symptoms may develop early or late, may disappear upon the removal of the dressing, or may persist—most often follow the use of large amounts, but the reverse has been observed.

Bismuth subnitrate is non-irritant, desiccant, but poisonous when used in large quantities: it may be employed as powder, emulsion, or ointment.

Zinc oxide is a weak, non-poisonous, desiccating substance, and may be employed in the same way as bismuth.

Acetanilid is far more powerful than the preceding two, is safe and efficient; the powder is simply dusted over wounds.[1]

Treatment of Wounds.[2]

A wound is a solution of continuity suddenly effected by anything which cuts or tears. When the skin remains intact the injury is a *sub-*

[1] Pages might be filled with accounts of other chemical compounds which have been recommended, but the most reliable and commonly accessible have been described.

[2] *Vide* also Chapter XXII.

cutaneous wound, and little if any constitutional symptoms result, the lesion being repaired by those reparative processes erroneously called simple adhesive inflammation or aseptic inflammation. Wounds are termed *incised* when caused by a sharp-edged object; *contused*, when produced by a more diffused force dividing the tissues, leaving the wound-surfaces bruised; *lacerated*, when irregularly torn; *punctured*, when the depth much exceeds the superficial area.

Incised Wounds.—The pain is apt to be less than in the other varieties, because the tissues are cleanly divided, the vulnerating object not dragging upon or injuring contiguous sensitive parts. Bleeding tends to be freer than in lacerated or contused wounds, varying with the vascularity or structure of the tissues. Thus, facial wounds bleed freely, even if no considerable vessel be divided; scalp-wounds, not only because of the free blood-supply, but because the vessels cannot readily contract and retract in the dense tissues. Retraction of the edges of incised wounds always occurs, varying with the subjacent structures and the line pursued. Proper planning of incisions therefore may lessen the number of sutures requisite. Skin and fascial wounds passing across the course of underlying muscular fibres gape widely. If made parallel to their course, they will remain in contact or require but few sutures. Skin and muscle retract most freely when the former is divided across the line of cleavage,[1] the latter at right angles to its fibres: inflammatory tension of subjacent parts increases gaping.

Union of Incised Wounds.—Under proper treatment (see p. 354) the normal reparative processes described in Chapter XXIV. effect repair. Locally, where the epithelium is thin, the wound-edges may present a faint blush for forty-eight to seventy-two hours: they are perhaps slightly swollen, warmer than normal, and tender; but all these symptoms are often absent. Although union appears to be firm at the end of seventy-two hours, it is mechanical, not vital—*i. e.* it is a mere gluing together by cellular exudate and fibrin. A few days suffice to complete true healing, a narrow reddened line indicating the former cut, which gradually fades until only a faint white scar remains.

If true inflammation—*i. e.* germ-infection—occurs, the faintly reddened wound-edges soon become decidedly reddened, swollen, and tense; throbbing pain is complained of, union fails, and pus appears. A chill or rigor may occur, but some headache, fever, anorexia with coated tongue, and constipation are noticed in varying degrees, with diminution in and high color of the urine. Symptoms of nervous disturbance, varying from mere restlessness to delirium, will make their appearance: septic traumatic fever has commenced. With effective drainage and antisepsis both local and general symptoms tend to diminish and disappear, but healing now can only occur by granulation, the old "healing by the second intention." When two surfaces covered by healthy aseptic granulations can be maintained in contact, fusion often occurs, and healing by "secondary adhesion" or by "third intention" takes place: upon this fact depends the success of secondary suturing.

TREATMENT.—Sterilization of hands, instruments, and the surrounding parts must precede examination of any variety of accidentally inflicted wound. Bleeding may temporarily be checked by a tourniquet, pressure on the main vessel, or aseptic compression in the wound. *Arrest* the *hemorrhage* permanently by torsion or ligature. After some operations, even when all visible bleeding points have been tied, free oozing

[1] See Langer's observations.

persists, notably in some cases of intracranial excision of the semilunar ganglion or brain-tumors. Again, in all wounds of cerebral sinuses or other large veins ligatures may be difficult of application. In either instance, especially the former, tamponade with iodoform gauze should be employed. If the oozing has been mainly from small veins, forty-eight hours commonly suffices, when secondary suturing may be done, the wound healing as if primary closure had been made. If a large vein has to be occluded, at least a week should elapse before removal of the packing.

Remove foreign bodies with forceps and *clean the surfaces* with a gentle stream of aseptic salt solution, sterilized water, or antiseptic lotion, carefully avoiding distention of the wound-cavity. If the dry method of operating be employed, gentle pressure with sterilized gauze pads or absorbent cotton serves for cleansing. With an irregular, deep wound, especially in poorly vascularized tissues, one of two courses must be pursued: (1) *buried sutures* must be so disposed as to efface all spaces in which blood or serum can collect, or (2) *free exit must be afforded*, primarily for blood, later for exuded serum: although the coagulable portion of wound-discharges contains enough nucleins to be germicidal, serum does not. Drainage is only requisite for an aseptic wound for twenty-four to forty-eight hours to prevent the accumulation of serum which will break down the mechanical bond of union effected by the coagulated exudate, and thus delay union. If infection has taken place or the success of disinfection be doubted, drainage is certainly indicated until the dangers of sepsis are passed. *Rest of the parts* by position, splints, compresses, and gentle bandaging will secure prompt union of the deep as well as superficial parts, thus doing away with much of the necessity otherwise arising for drainage.

Incised wounds are best closed by sutures, which may be interrupted or continuous. Union of cut muscle with muscle, fascia with fascia, and skin with skin by buried sutures is the ideal plan, the skin stitches being passed through the dense corium, avoiding the epithelium with its possible germs and stitch-abscesses and the certain scarring of the needle-punctures.

When strain is probable on the coaptating sutures, relaxation sutures may be employed, but are seldom requisite. Absorbable sutures are preferable, especially when buried, because not giving rise to future trouble, as the non-absorbable sometimes do, nor requiring removal when passed through the skin. Any pliable substance, such as silk, silkworm gut, catgut, kangaroo tendon, or silver wire,[1] can, however, be safely employed for a perfectly septic wound.

Coaptation sutures must only be tight enough to bring the surfaces gently in contact, less constriction impair the vitality of the tissues and favor suppuration. Strain can sometimes be advantageously removed from the coaptation sutures by *relaxation sutures*, but they ought seldom to be requisite.

Needles should never be larger than requisite to carry the thread, and may be straight, curved, or partially curved, depending upon whether the wound is on a free surface, a concave, or a convex one.

[1] See Bolton's experiments as to the germ-inhibitory or germicidal action of certain metals, especially silver. Subepithelial sutures of silver wire are the most satisfactory of any of those mentioned, but require removal at the end of ten days to a fortnight.

Round sewing-needles are best for suturing the bowel, bladder, or peritoneum. Strips of gauze fixed first on one side of the wound by collodion and then on the other after it has been approximated, are sometimes excellent substitutes or succedanea to sutures. This expedient can be advantageously adopted after removal of sutures to support the line of union. Adhesive plaster must *never be used to directly approximate* a wound, but may be employed to take strain off stitches or to support a recent scar if sufficient aseptic gauze be interposed. Aseptic compresses and bandages, exercising pressure through superimposed elastic materials, such as sterilized cotton, oakum, etc., serve as adjuvants to suturing by promoting drainage, securing quiet of the deeper parts, and thus relieving strain upon the stitches. In small uncomplicated operation-wounds, where no drainage is requisite, *catgut sutures* may be used and the whole line sealed by a strip of gauze saturated in iodoform or even plain collodion, or sterilized silver-foil may be employed. Aseptic or antiseptic gauze in amount proportioned to the expected oozing must next be laid in place. When germicides are employed some form of protective should cover the wound. Outside of all, abundance of sterilized absorbent cotton should be used, being secured in place by a firmly applied bandage, carefully avoiding all constriction. If a limb is involved, proper splints should secure quiet; if the thorax be concerned, the arm of the corresponding side should be secured; if the neck, a stiffened collar or dressing is advisable.

Indication for Change of Dressing.—Dressings should *never be changed except for good cause.* If penetrated by discharge at some spot or spots, and prompt drying at the margins of the stained area tends to occur, a pad of aseptic gauze had better be secured over the stained spot rather than undress the wound; but if the dressings are thoroughly soaked, the superficial portions must be changed, leaving those immediately related to the wound unchanged if possible. When drainage-tubes require removal dressings must be changed, usually about the fourth day. If filled with firm clot, the wound is aseptic and the tube should not be replaced; when doubt exists as to the asepticity, drainage had better be continued until this question is settled. A sustained temperature unexplainable by complications external to the wound demands inspection, since drainage may be defective or infection have occurred.

Constitutional Effects of Wounds.—It is a common mistake to expect no constitutional symptoms after wounds or operations, and when they arise to ascribe them invariably to infection. After the nausea, vomiting, pain, and often subnormal temperature of the first few hours some rise of temperature occurs in about two-thirds of thoroughly aseptic cases, but the patient has a clean, moist tongue, the pulse is not usually much accelerated, the appetite is unimpaired, and the intellect clear.

This *aseptic fever* results from the absorption of fibrin-ferment and nucleins and is seen in subcutaneous fractures. (*Vide* Chapter VII.) It begins as soon as reaction from shock is established, gradually but promptly subsides, and the general condition is frequently not noticeably altered. The local pain diminishes in proportion to the time which has elapsed since operation, and there is no tenderness of the neighboring lymphatics. True wound-fever from infection commences later, on the second or third day, is often preceded by chill or rigor, and the local pain increases and the pulse and nervous symptoms clearly indicate a systemic intoxication.

Symptoms of Lacerated and Contused Wounds.—As some degree of contusion is usually combined with laceration, these two classes of wounds will be considered together. Pain is greater than in incised wounds, but hemorrhage is not so marked. Where contusion preponderates, much blood is extravasated in the tissues, interfering

with the circulation; hence sloughing is usually proportionate to the contusion, as is also the risk of secondary hemorrhage when the dead parts separate. *Sloughing and profuse suppuration* will occur in a certain proportion of cases despite all efforts at antisepsis. *Septic cellulitis and gangrene* and any form of sepsis may occur, the former often resulting in extensive sloughing and producing serious scarring.

TREATMENT OF LACERATED AND CONTUSED WOUNDS.—It is difficult to render these wounds thoroughly aseptic, but no reasonable effort should be spared. *Temporary sterilized or antiseptic dressings* must be used until efficient antisepsis can be secured. The preliminary precautions mentioned under Incised Wounds must be adopted. *Free irrigation* with an efficient chemical germicide should be employed, exposing and disinfecting under anæsthesia if necessary every recess. Many cases will do better with light iodoform-gauze packing. When seen later, after infection is well advanced, *incisions to liberate pus*, sloughs, and the contained poisons, and to relieve tension, free irrigation and drainage by tube or packing, or by both, become requisite. If the form and location of the wound ensures free escape of wound-fluids, no drainage is requisite, but if drainage is needed, tubes must be employed until the discharge becomes aseptic and small in amount.

Slight trimming of the margins of a face-wound is permissible to secure primary union and a smaller scar, but even here unaided nature is often equal to the task, any serious deformity being remediable later by operation. The same advice applies to hopelessly damaged structures in slightly vascular parts, but for the scalp, oral cavity, or face the surgeon should usually rely on antisepsis. *Sutures* are only applicable to the face, where good results often follow their use.[1] *Rest* secured by voluminous aseptic dressings, splints, and position, with (possibly) the external application of dry cold, is often useful. Where much contusion exists cold should be employed tentatively, watching lest the sloughing should be increased. When spreading cellulitis and free suppuration occur, proper incisions, followed by continuous antiseptic irrigation or the *continuous bath*[2]—warm or cold according to the vitality of the tissues—is usually better than a closed dressing.

Punctured Wounds.—These much exceed in depth their width, and result from pointed objects, as knives, swords, nails, stakes, etc. *Especial dangers* attend these wounds, such as *dangerous hemorrhage* (primary or secondary) from the deep vessels, damages to important *nerves*, *penetration of cavities*, and deep, widespread *septic inflammation*.

If a smooth, uninfected instrument—as a trocar—inflicts the wound, no trouble results, but when a rough object, as a board-nail or stake, is the vulnerating object, almost necessarily harboring germs, the results differ, as fragments of tissue, pieces of clothing, the softened inner sole of a shoe, may be, and they often are, torn off and deposited in the depths of the tissues, the tissue-fragments usually themselves being infected, as the fragments of the foreign bodies always are. While the change of relation of the wounds in the various planes of tissues interferes with the escape of exudates, and this favors spread of an infective inflammation, in itself it does not initiate such a process. This mechanical fact does not alone explain the gravity of punctured wounds, while the combination with infection does.

SYMPTOMS.—These must vary so with the tissues and parts involved—nerves, vessels, or cavities—that no general description can be given.

[1] Subepithelial, when possible, to avoid scarring.

[2] If poisonous substances be employed, any symptoms indicating their absorption must be carefully watched for.

Treatment.—Hemorrhage must be arrested if serious after enlargement of the wound. Any divided nerve must be sutured. Where infection has occurred thorough disinfection, including removal of any foreign body, must be effected by incisions, irrigations, etc. under anæsthesia. Drainage-tubes reaching to the bottom of the wound, possibly a counter-opening, and absolute rest by splint and position, are demanded. If septic inflammation follows, sufficient incisions, counter-openings, and the treatment suggested for contused wounds must be employed. If the brain-case, spinal column, thorax, or abdomen be penetrated, effective disinfection and drainage are indicated, demanding an exploratory operation in most instances, certainly if infection is known or strongly suspected to have occurred.

Constitutional Treatment.—This is rarely of importance, certainly immaterial if infection does not occur. Simple, easily-digested liquid or soft food is advisable for the first two or three days, after which, if the bowels act naturally and fever is absent, ordinary full diet may be given when the patient desires it. Forced alimentation may be requisite to relieve the effects of severe hemorrhage or the previous drain of pus. Stimulants, as alcohol, ammonia, strychnia, digitalis, quinine, etc., will often prove useful. Proper emptying of the bladder must be ensured. The renal and alvine secretions must be normally maintained or even stimulated, especially where sepsis is present, to get rid of toxic substances and germs. Sleep in proper amount must be secured, especially for the young and the old, even by drugs when necessary.

PART V.

SURGICAL AFFECTIONS OF THE TISSUES AND TISSUE-SYSTEMS.

CHAPTER XXVI.

CYSTS AND TUMORS.

BY ROSWELL PARK, M.D.

GENERAL CONSIDERATIONS.

A tumor *is a new formation, not of inflammatory origin* (i. e. *not due to the presence of as yet recognized and determined parasitic agents*), *characterized by more or less histological conformity to the tissue in which it has originated, and having no physiological function.*

The above is perhaps as good a working definition of the term *tumor* as can be given in a few words. Nevertheless, it needs explanation in more than one direction. By the above definition it is purposely intended to separate the new growths now to be considered from a distinctive class of neoplasms which are positively of inflammatory (*i. e.* of infectious) origin, to which the generic term of *infectious granulomata* has been given, and which have been dealt with as amply as space will allow in Part II.

In that portion of this work a variety of common surgical disorders, such as tuberculosis, syphilis, glanders, leprosy, etc., were considered, while others more or less rarely met with were alluded to whose distinctive anatomical lesion consists of new growths of this kind. These are tumors which certainly possess no physiological function, but are of parasitic origin; and between them and those hereafter to be considered it is intended to make the most accurate possible distinction. As between tumors and tissue new formations which are diffused—as in the overgrowth of a given part, hyperplasia being due to persistent hyperæmia or to compensatory changes—there is this distinction to be made, that in these instances there is more or less assumption of physiological function, or more or less of useful purpose achieved, by the new tissue-elements, whose business is to atone for previous defect, to repair, or to strengthen. Such new growths are rarely, if ever, strictly circumscribed, while the majority of tumors are.

Again, as between certain outgrowths or exuberances of development and tumors in the same locations and of the same tissue it is not always easy to make a distinction. An exuberant deposit of calcareous material or callus can scarcely be considered to constitute a true tumor so long as it serves the purpose of strengthening a part. On the other hand, if it assume irregular and inconsequent shape

and position, and appear to subserve no useful purpose, it may then be considered a tumor. A simple enlargement of a bony process which has its place in the normal anatomy, either of man or of his predecessors, is seldom to be regarded as a true tumor, because its purpose was useful—if not in man at least in his ancestors. This is true, for instance, of the supracondyloid process, which sometimes assumes large proportions, but is to be regarded rather as an exostosis than as a true bone-tumor, the distinction being that in the latter case there has never been the semblance of usefulness.

Lastly, while in the definition above given it has been stated that tumors are not due to parasitic activity, it is to be distinctly understood that this refers to organisms at present accurately recognized or known to be concerned in the production of disease in the human race. It will be necessary shortly to take up the parasitic theory of the production of certain tumors, and, lest the reader might find apparent contradiction, this disclaimer is inserted at this point. There is good reason to suspect the parasitic nature of at least growths of a certain class, but the biological position of these supposititious parasites is not yet established, nor is their rôle as causative agents positively demonstrated.

In the past exceedingly vague notions have prevailed concerning the *nature* and *origin* of tumors, and, while the clinical observations of writers of past generations will never lose their value, the ideas which have prevailed concerning their pathology constitute interesting reading in an historical sense, but are now of relatively small value. Accurate notions scarcely prevailed until Virchow, for instance, demonstrated that tumor-cells in no wise differ from cell-types which are met with either in embryonic or in adult tissues. Tumors, like all other parts of the body, are built up of cells, and the points concerning which we now most want light are with regard to the influences which determine cell over-production in these characteristic forms. Concerning the variety of views that have prevailed at different times (their number being large), this is scarcely the place in which to offer even an epitome. I shall therefore take up but a few of the numerous explanations which have been offered to account for tumor-growth, and must emphasize distinctly, and at the outset, that, according to our present light, there is no one explanation sufficient to cover all cases, but that in all probability it is now one cause and now another which may determine this peculiar form of cell-activity.

The **spontaneous origin** of tumors was a view adhered to in time past by men of erudition, but is essentially a cloak for ignorance, since to confess that a tumor grows spontaneously is simply to acknowledge that we know nothing about it. This theory, then, may be completely discarded.

Dyscrasia has been advanced by men of surgical eminence as accounting for tumor-growth. It would appear that this also is a delusion, and that the condition, in which patients with tumors that cause loss of strength, etc. are found, is the result rather than the cause of their presence. There is no known dyscrasia which by itself is known to give rise to neoplasms.

Diet is regarded by some as an explanation for many of these instances. While it is undoubtedly true that peculiarities of diet have much to do with nutrition, there would be much more to substantiate this view could it be proven that particular diet led always to this result. While there is no doubt but that restricted regimen of one kind or another may bring about diathetic conditions, there is as yet reported no sufficiently extended experience which will permit us to give anything

more than a tentative adherence to the view that diet has much to do with the production of tumor, particularly of cancer. It has been claimed, nevertheless, that while of phosphides or *compounds of phosphorus* in excess are of *beneficial influence in the diet of tubercular patients, they predispose to cancer-formation.* This claim has been ingeniously defended, especially by certain English writers, and may prove to have more in it of value than is yet really substantiated. Among the laity prevail most foolish and puerile superstitions, to which not the slightest importance should be attributed.

Heredity seems to be a factor of some importance, since it is impossible to deny that now and then we meet with striking instances in which several members of one family are sufferers from tumors, particularly of malignant type. We sometimes trace a history to this effect through three or four generations; and, while it may be something in the environment rather than something which is transmitted from parent to offspring, there is, nevertheless, good reason to think that heredity is a factor of importance in this direction. Should this hypothesis in the future be positively proven, there is yet no knowledge in our present possession which may explain the kind of tendency which is thus transmitted.

Perverted nerve-influence is an explanation which probably has in it more than we can at present distinctly define. The influence of the nervous system over cell-growth and changes, and consequently upon tissues, is by no means yet well defined, and is a subject upon which investigation is most urgently needed. The effect of the nerves upon nutritional changes is readily conceded by all, but the laws which regulate it are not yet understood. One of the best explanations which is to-day afforded for the undoubted increase of cancer is the influence of the nervous system, disturbed as it seems to be by causes connected with so-called civilization—in other words, with the high-pressure life which modern society entails, and the artificial conditions, accompanied by the mental worry, which seem inseparable from our modern ways of acting and of doing business. These few words in all probability mean much more than one can clearly express, but are perhaps sufficiently explicit to indicate at least that much may be expected from a more accurate study of the nervous system.

Irritation and Trauma.—The effort is often made to explain the presence of tumors upon the hypothesis or the known fact of some previous injury, trifling or serious. It undoubtedly is often the case that tumors appear in sites where there have been previous traumatisms, but this sequence of events by no means proves a definite relation of cause and effect. On the other hand, there are certain forms of irritation which are so often followed by tumor-formations that one is never surprised upon meeting with them. Probably no woman escapes without one or more bumps or bruises upon the breast, yet they do not produce tumors of the breast in anything more than a very trifling proportion of cases. *Per contra*, upon the lower lip of inveterate clay-pipe smokers and the scrotum of chimney-sweepers there develop certain forms of malignant ulcer (epithelioma), which so often and so significantly follow upon the irritation thus produced that it is impossible to avoid conviction that the one is the cause of the other. Should events

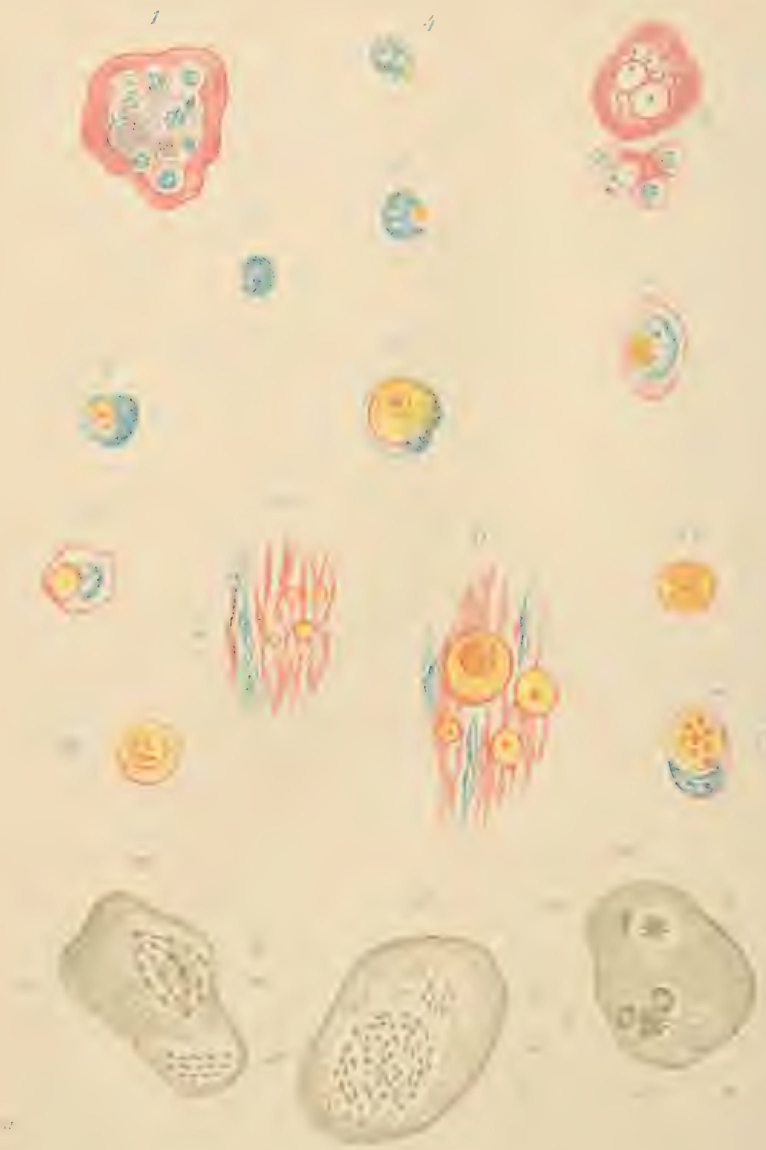
prove the parasitic nature of any of these growths, they may also prove that the irritation causes surface lesions through which infection easily occurs. At all events, at present it may be accepted as a fact that tumors, benign and malignant, not infrequently follow irritation and trauma, but by no means with certainty.

Inflammation.—This must refer to inflammation in the sense in which it has been used by older writers, implying a very variable condition, sometimes including, sometimes excluding infection, and being a term covering a somewhat confused mixture of irritation, hyperæmia, infection, etc. In so far as it concerns inflammation as alluded to in the present work, it should not be here included, since inflammation (*i. e.* infection) produces neoplasms of a class considered in Part II. and distinctly ruled out from present consideration (*i. e.* the infectious granulomata).

If, then, while inflammation in this former sense is more than hyperæmia, it may be regarded as predisposing to cell-activity, but not necessarily to tumor-formation as distinguished from hypertrophy of a given part or tissue. If it refer to irritation, this has been already acknowledged as one factor in the etiology of tumors, but as a very uncertain one. The cancer of the gall-bladder or liver which occasionally results from the irritation of a gall-stone, or the cancer of the breast that follows eczema of the nipple, may be regarded in this light as additional illustrations if one prefers to interpret them in this way. If, finally, by inflammation be meant the infectious granulomata, they have already been considered. As the term " inflammation " can scarcely mean anything except hyperæmia, irritation, or infection, we seem to have pretty completely ruled it out from consideration as by itself an active cause leading to tumor-formation.

The Embryonal Hypothesis of Cohnheim.—This in its ingenuity and in its applicability is a most fascinating explanation, which is undoubtedly sufficient for at least a certain number of instances. According to Cohnheim, only one causal factor for tumors exists—*i. e. anomalous embryonic arrangement*. He regards them as *entirely of embryonal origin*, no matter how late in life they may develop and appear. Briefly summarizing his views, they are to the effect that in the early stages of embryonal development there are produced more cells than are necessary for the construction of a certain part, so that a certain number of them remain superfluous. While this number may remain very small, they possess, on account of their embryonal nature, a most potent proliferating power. This superfluous cell-material may be distributed uniformly, in which case it will develop whole system-arrangements, like supernumerary fingers, etc., or it may remain by itself in one place, and will then develop a tumor. In this latter case the tumor may appear promptly or not until late in life, according to the time at which the cell-collection receives the necessary stimulus, or because of its suppression by resistance of surrounding structures. It may be an irritation or an injury, such as above alluded to, which shall give it this stimulus ; as, for example, it is reasonable to think that certain nævi and other congenital conditions which develop later into cancers do so in accordance with this view. Surgeons generally find little fault with Cohnheim's hypothesis, except that as yet they decline to see

PLATE XII.



ILLUSTRATIONS OF THE ALLEGED PARASITES OF CANCER.

[illegible]

[illegible] Jackson Clarke; Zeiss 1-12; Biondi's stain.)

[illegible] in 8 had a diameter of one mikron.

8, 9. Nuclei of Sarcoma Cells appearing through the Sporozoa (i. e., translucency of the latter).

[illegible]

12. Nuclear division in Sporozoon.

13, 14. Endogenous division of the Sporozoon. (After Vedeler.)

[illegible] matin bodies; *b*, Spore; *c*, Parasite (Acinetaria).

[illegible] plasm of the Parasite

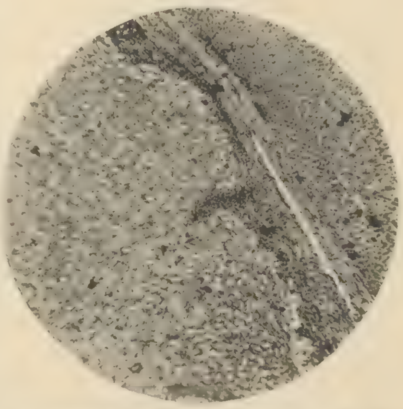
[illegible] Biondi-Ehrlich stain.)

in it an explanation for all cases. Nevertheless, for dermoid and teratomatous tumors and for all heteroblastic tumors it seems to afford the only tenable explanation. Thus, chondroma of the parotid and of the testicle are most easily explained in this way, and that cartilaginous islands occur in the shafts of adult bones is well known.

The **parasitic theory** of tumor-formation is one which has been vaguely hinted at for a considerable length of time, and which has only very lately taken anything like distinctive form. It implies that tumors (and most writers limit it to the malignant tumors) are due to the irritation produced by *parasitic agents* of some kind, which, introduced from without, act as do the bacteria in the now well-known infectious granulomata. This also is in certain respects a satisfactory theory, and has more or less in clinical experience to justify it, while, at the same time, at present there is but little upon which men can agree in the microscopical appearances of these growths to corroborate it (Plate XII.).

At present students are concentrating their investigations mainly upon the class of unicellular animal organisms belonging in a general way to the *coccidia*. It is definitely established that coccidia, which are a class of the *sporozoa*, are the cause of certain well-known disease-manifestations in the lower animals, as, for example, in the livers of rabbits. Minute organisms, resembling these, differently classified and regarded by different investigators, have been found in and about the distinctive cells of numerous cancers and sarcomas, and have given rise to the greatest difference of opinion, some holding that they were there accidentally, some that they were the actual disease-agents, and others that the bodies thus regarded by some as parasitic animal forms were in effect mere evidences of karyokinetic cell-division or of breaking up, in some sense, of cell-contents or tissue-débris; in other words, that they were not parasites at all, but results rather than causes of disease. At present writing the controversy is still actively waged, and one may not yet surely say which party in the discussion is correct. From the pathological side the principal objections to this view are that these little bodies have not yet been positively identified by enough observers to justify their acceptance by all, and that so far their endeavor to cultivate and inoculate them has failed. It should be emphasized that it is not claimed that any of these organisms are bacteria, but it is generally supposed that they belong rather to the animal than to the vegetable world. From the clinical side there is much to justify the parasitic theory. That cancer prevails in certain families and localities, and even in certain houses (the so-called *cancer-houses*), is now well established; that it is capable of being spread from one part of the body to another by mere contact is established, as from the lower to the upper lip, from one labium to the other, etc.; and that it acts in almost every way as do well-known parasitic lesions is frequently seen. Thus, its *contagiousness and inoculability* have received enough clinical demonstration to be suggestive, if not widely acceptable as definitive; and, in spite of all statements to the contrary, there are enough inoculation-experiments from man to the lower animals or from these to each other to place it now beyond possibility of denial that cancer can be transmitted from man to the animals. It is, then, not yet possible to state with any distinctness that the parasitic theory of tumor-formation is as yet tenable. One must, at least, however, say that it has much to commend it, and that it certainly deserves the earnest consideration of individuals and the collective investigation of the entire profession.

FIG. 146.



Psorosperms in rabbit's liver (Spencer, ½″ obj.).

Nomenclature.

As may be expected, when one takes into consideration the crude notions and the vague, contradictory statements that have obtained in the past concerning the nature of tumors, their nomenclature has been sadly confused; and if some new terms are introduced to-day, it is wise, perhaps, rather than to hold to some of those which have done duty in the past for varied and varying conditions. Various systems have been followed of naming them according to their supposed nature or their evident tendency, or according to some purely arbitrary classification; thus we have the distinction into *homologous* and *heterologous* or *heteroblastic*, according as they are similar to or variant from that tissue in which they seem to originate, or they have been spoken of as *benign* and *malignant* according to the disposition which they evince; and these terms are to-day in sufficiently frequent use to demand acceptance. In fact, the distinction as between benign and malignant is both convenient and in some respects accurate, implying little with regard to histological structure, but everything with regard to their effect upon the individual.

Still, contradictions will arise even in using these simple terms, as, for instance, a fibroma, which ordinarily is an innocent type of tumor, but which when growing from within the skull may so press upon the brain as to produce death, or which might press upon some important organ or passage-way and again prove fatal. Thus a tumor usually innocent may be malignant by accident of location. On the other hand, those tumors ordinarily spoken of as malignant—known to the laity as cancers—evince always their destructive tendency, no matter where located or at what age appearing.

So far as *method of classification* goes, the *anatomical* (*i. e.* the *histological*) has proven so far the most satisfactory, and is that which is now everywhere adopted. It is the basis for the classification followed in the ensuing pages. But even here it is impossible to maintain abrupt or always accurate distinctions, because tumors are frequently of mixed type, and require us, if we desire to express their composition by their names, to sometimes combine words in an awkward fashion. By common consent that tissue which predominates furnishes the concluding portion of the compound term, while by prefixing other terms we endeavor to imply the composite character of the neoplasm.

Thus we have *osteo-chondroma*, *fibro-myoma*, *myo-fibroma*, etc., and it is necessary often to reduplicate terms in order to be accurate in description. While this complicates phraseology, it nevertheless furnishes to the intelligent reader a reliable clue as to the general character of such a growth; and if one reads, for instance, of a *myxo-chondro-sarcoma*, he promptly infers therefrom that he has to deal with a tumor essentially a sarcoma, in which both myxomatous degeneration and cartilaginous formation have taken place. In the same way, the prefix *cysto* is frequently used to imply a combination of originally solid tumor which had undergone cystic changes in whole or in part.

The old term *cele* is even to-day frequently used as a suffix, implying neoplastic changes in an organ, or at least the formation there of a tumor. Thus we have *bronchocele*, *hydrocele*, *cystocele*, etc. Again, certain terms are now used in a different sense from that originally intended. Thus, the term *sarcoma* now has a definite significance, whereas originally it had little meaning and was applied inadequately and indiscriminately. Old terms also, like *fungus hæmatodes*, are now used rather in a descriptive sense, because for any such tumor on accurate examination we can find a proper term taken from descriptive pathology. Consequently, it happens that the student of to-day must read the works of the older

writers, especially concerning neoplasms, with a certain amount of intelligence, as well as of apology for the inaccuracy and misnomers of the past.

Treatment.

The results of treatment of tumors leave much still to be desired, particularly when dealing with those of malignant nature. So far as purely internal treatment is concerned, we have not yet discovered drugs which with any certainty influence cell-growth to the extent of making them reliable or effective. In the past, and even the present, numerous remedies have been advocated as having more or less of power in this direction. Of them all it is probable that arsenic in some form is more efficacious than any other. This is certainly true in the case of the disease elsewhere spoken of as *malignant lymphoma*, or *Hodgkin's disease*, which partakes much of the character of some of the other neoplasms. But to say that arsenic alone or any other known remedy can be relied upon at all times is probably going too far.

The treatment of all operable tumors, then, is *essentially surgical* (*i. e. operative*), although it must be confessed that to a large extent results are based upon the essential character of individual tumors. But at least this much can be positively stated, that to be successful in the removal of *any* tumor its complete extirpation is demanded. Even the most benign tumors will return if only partially removed. This is true even of innocent cysts, which will often be re-formed if a portion of the cyst-wall be allowed to remain. Complete extirpation is ordinarily a simple measure when tumors are *encapsulated*, as many of the innocent tumors often are. On the other hand, the performance of some of these operations is made difficult and hazardous by the location of the tumor, as in many large uterine fibroids, tumors of the thyroid, etc. But when dealing with malignant tumors the only secret of success is to extirpate them in the most merciless possible manner, sacrificing everything which may appear to be involved, unless, like a large blood-vessel or important organ, it be essential to the life of the part or of the individual. These general statements are made when speaking of tumors in a general way. More particular directions will be given when dealing with particular forms or in the chapter on Special and Regional Surgery. (*Vide* also the Treatment of Malignant Tumors by Inoculation, Appendix to this chapter.)

Classification.

Following custom in large degree, yet being guided by generally undeniable facts concerning histological structure, tumors will be classified and considered as follows:

1. Cysts.
2. Dermoids.
3. Teratomata.
4. Tumors of immature mesoblastic tissue-type.
5. Tumors of simple mesoblastic tissue-type.
6. Tumors of more complex mesoblastic tissue-type.
7. Tumors of epithelial type or of epiblastic origin.
8. Tumors of glandular tissue-type.
9. Tumors of endothelial type.

1. CYSTS.

A cyst may be defined as a *tumor containing one or more cavities filled with fluid or semifluid contents.* This specifies nothing with regard to the location nor the character of the cyst-wall nor the nature of the fluid contents. Following Sutton, I divide cysts into four groups:

1. *Retention-cysts.*
2. *Tubulo-cysts.*
3. *Hydroceles or Distention-cysts.*
4. *Gland-cysts.*

Retention-cysts.—These imply a previously existing cavity whose outlet is obstructed and whose contents consequently accumulate, often to such a degree that the original character of both containing wall and contained fluid is entirely altered. When this occurs in glands or gland-ducts there is usually complete atrophy of gland-tissue, providing sufficient time have elapsed. Such cysts are, then, due either to permanent or temporary arrest of flow. In *hydronephrosis*, for example, there is obstruction of the renal outlet and dilatation of its pelvis, with partial or complete atrophy of the kidney-structure, until a cyst of enormous size may be present. When a similar condition obtains in the uterus, as by obstruction of the cervix, perhaps due to injury done during labor, we have a condition known as *hydrometra*, seen occasionally in women, often in the lower animals, and particularly in those having a bicornate uterus, causing a condition often mistaken for an enormously dilated Fallopian tube. Similarly, when the common bile-duct is obstructed, which may be due to impacted gall-stones, to inflammatory lesions, tumors, etc., we may have such backing up of bile in the gall-bladder as to produce the condition known as *hydrocholecyst*.

Under any of these circumstances pyogenic bacteria may produce infection which will be more or less promptly followed by suppuration; and then, instead of *hydronephrosis*, *hydrometra*, *hydrosalpinx*, etc., we get *pyonephrosis*, *pyometra*, and *pyosalpinx*.

Tubulo-cysts.—These are *cystic dilatations of certain functionless ducts and obsolete canals* which no longer serve a useful purpose. They comprise—

1. *Cysts of the Vitello-intestinal Duct.*—Cysts originating from this functionless duct occupy the umbilical region, sometimes projecting externally, sometimes internally. They are usually lined with mucous membrane furnished with villi and columnar epithelium. Such a cyst may possibly be confounded with an umbilical hernia. These cysts occasionally open at the umbilicus and discharge irritating material, sometimes fecal matter. Cystic dilatation of the portion of the duct originally connected with the ileum is also occasionally met with.

2. *Allantoic Cysts.*—These are connected with the urachus, which should ordinarily be found as a fibrous cord, but which occasionally persists in a pervious condition, in whole or in part. At birth it is often traversed by a very narrow canal lined with epithelium continuous with that of the bladder. The urachus lies outside the peritoneum, and may be dilated at any point between its two extremities. When the entire urachus is pervious urine is discharged from the navel.

3. *Cysts connected with Remains of the Wolffian Body.*—The Wolffian

body, or the mesonephros, is intimately related with the development of the kidney, the ovary, and the testis. In the two latter locations glandular elements may be met with, persisting in adult life.

In the male the *tubules* persist as *excretory ducts from the testis*, but in the *female* they persist in a vestigial condition as the *parovarium* and *Gärtner's ducts*. The ovary proper consists of the *oöphoron* and the *paroöphoron*, the former being the egg-bearing portion, the latter receiving the tubules from the adjoining structure known as the parovarium. The *paroöphoron* gives rise to cysts which burrow deeply between the layers of the broad ligament, make their way alongside the uterus, and raise the peritoneum. It is a peculiarity of these cysts that their inner walls often become *papillomatous*, and may even develop such a crop of warty outgrowths that these make their way through the cyst-wall and protrude into the abdominal cavity, where they sometimes become detached and are dropped as loose bodies into the peritoneal sac. The condition is also often accompanied by warty growths upon the peritoneal surfaces. These need give rise to no alarm, because they usually disappear spontaneously with removal of the tumor. *Paroöphoritic cysts* are to be distinguished from *parovarian* cysts, which develop from the parovarium, this latter consisting of a number of tubules situated between the layers of the mesosalpinx, composed of an outer series of tubules known as *Kobelt's*, an inner set, about a dozen in number, known as the *vertical* tubules, with a straight tube running at right angles to these through the broad ligament to the vagina, known as *Gärtner's* duct, which is homologous with the vas deferens of the male. Cystic dilatation of Kobelt's tubes is often met with, these cysts being very small and having no clinical importance. Cysts arising from the vertical tubules are usually transparent until they attain considerable size, when their walls thicken. Their contained fluid is not harmful, and after rupture of such cysts internally the fluid is absorbed, and thus disposed of. Such cysts may rupture and refill several times. *As between the paroöphorous and parovarian cysts*, the latter are usually easily enucleated, carry the ovary upon one side, and have the Fallopian tube stretched over them without communication.

The internal sections of *Gärtner's duct* are more often involved in animals than in women, but excellent illustrations of cystic dilatation of its various portions have been met with, usually in the walls of the vagina.

Corresponding to the above-mentioned conditions met with in the female we find in the male, as the result of changes in the Wolffian body, two quite common conditions—*encysted hydrocele of the testicle* and *general cystic degeneration* of the same. Like the ovary, the testicle is a complex organ with remnants of the mesonephros persisting among its ducts, while only a few of the Wolffian tubules remain. True encysted hydroceles arise sometimes in the efferent tubes of the testis, and sometimes in Kobelt's tubes (the same structures which in the female give rise to parovarian cysts), the two conditions, therefore, being analogous and homologous. These cysts, though closely associated with the testis, lie outside its tunica vaginalis. Their contained fluid is usually clear or of a milky whiteness, due to fat-globules. Sometimes it contains spermatozoa. Another variety is cystic dilatation of one or more of *Kobelt's tubules*, which is often described as involving the *hydatid of Morgagni*.

General cystic disease of the testis, known also as adenomatous degeneration, was formerly spoken of as hydatid disease of the same organ. The multiple cysts appear to originate in the remnant of the mesonephros still persisting known as the *paradidymis*. The cavities are lined with epithelium, and *papillomatous intracystic* formation is not uncommon. These tumors in time past have been unfortunately spoken of by a number of improper names, such as "cystic sarcoma," etc.

Hydroceles.—In time past this name also has been made to cover a multitude of conditions. At present, by common consent, when no other locality is spoken of, hydrocele of the tunica vaginalis is understood. (The term really implies a *collection of watery fluid in a previously existing serous cavity*.) This is the most common form.

Possibility of its formation depends upon the prolongation of the peritoneal cavity, which takes places in advance of or along with the descending testicle, and which in almost all the lower animals remains connected with the general cavity

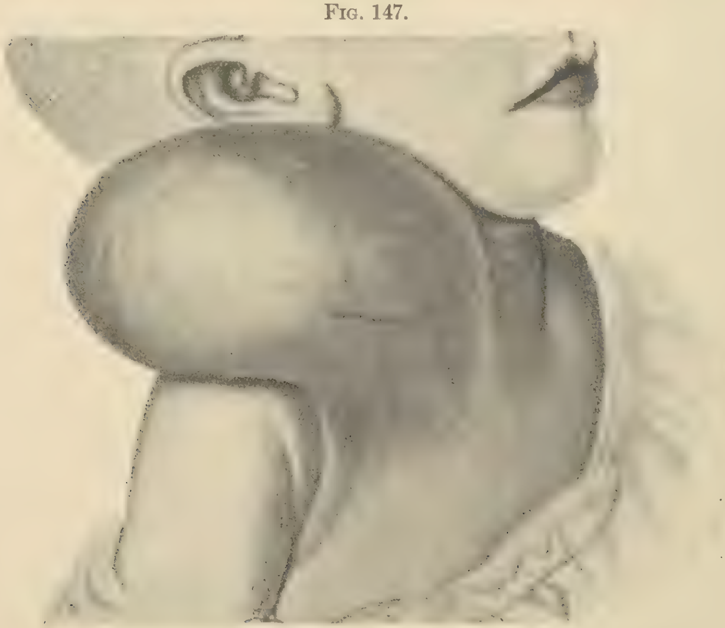
throughout life. In men only is it expected to close, even before birth. When the portion which extends along the spermatic cord is not completely obliterated we have *encysted hydrocele of the cord*, or *funicular hydrocele*, which is not common. The common form of hydrocele is constituted by serous effusion into the tunica vaginalis, and occurs usually without recognizable exciting cause. It will be treated of more fully in its appropriate place in Volume II.

The corresponding process of peritoneum in the female is known as the *canal of Nuck;* and, when persistent, this also becomes distended with fluid and forms a cyst known as *hydrocele of the canal of Nuck*, occupying the inguinal canal.

In many of the lower animals the ovaries are contained within a serous sac derived from the peritoneum which is connected with the opening of the Fallopian tubes, so that when the ova escape from the ovary they enter these tubes and pass to the uterus without entering the general peritoneal cavity. This ovarian sac is subject to serous distention, and constitutes a condition named by Sutton as *ovarian hydrocele.* An homologous condition obtains sometimes in the human female by pathological adhesion, and such cysts sometimes attain large size. They project from, and are intimately connected with, the posterior layer of the broad ligament.

Hydroceles of the neck, so called, are cystic collections of congenital origin found in the cervical region, due to dilatation of ducts or

Fig. 147.



Congenital hydrocele of neck.

clefts which should have disappeared at or before birth. The form of cyst to which the name of "hydrocele of the neck" is usually limited is recognizable at or soon after birth, and constitutes a fluctuating tumor, often extending beneath the clavicle into the axilla or down upon the thorax. They may occupy the entire lateral region of the neck, and may be unilateral or bilateral—may be single or multilocular, and may even intercommunicate (Fig. 147).

They originate always beneath the deep fascia. Some of these cysts are undoubtedly due to dilatation of lymph-spaces. This is particularly true of the

multilocular forms. There is noted in many of them a tendency toward spontaneous recovery, but many of them require operative measures for their eradication. Occasionally their walls are extremely vascular, even to the degree meriting the term *nævoid*.

Some of these cysts are considered by Sutton to be essentially examples of the laryngeal saccules which are met with as diverticula from the laryngeal mucous membrane, which undermine the deep cervical fasciæ of certain monkeys. These air-chambers, which are normal in the monkey, communicate with the larynx through the thyro-hyoid membrane, and occasionally run down beneath the upper border of the thorax. Many of the cysts having this resemblance are closely related to the hyoid bone and to the larynx, and there is very much to substantiate the view thus alluded to.

Glandular Cysts.—*Ranula* is an altogether too comprehensive term which has long been used in surgery, alluding to certain cysts met with for the most part in the floor of the mouth, and not indicating minutely their character nor their exact location. At present this term should either be restricted in signification or, perhaps, better still, be eliminated. If used, it should be confined to *retention-cysts* due to obstruction of the *submaxillary* or *sublingual* ducts. Such obstruction is often caused by salivary calculi impacted in the duct-orifices. In other instances it is due to cohesion of the margins of the outlet. A similar condition in the parotid duct is known, but is very much less common. Aside from this, certain other cysts originate from minute beginnings in and about the floor of the mouth, being due to dilatation of the mucous glands, particularly one near the tip of the tongue, sometimes known as *Nuhn's gland*. Dermoid cysts in this locality are not uncommon. In time past every cyst of the floor of the mouth was described as *ranula*.

Pancreatic cysts correspond in large degree to salivary cysts, the pancreatic duct becoming dilated by retention when its orifice is obscured; and, indeed, the condition has been spoken of as *pancreatic ranula*. Sometimes the canal is dilated in distinct portions, so that the condition resembles a string of cysts; at other times it is the terminal portion which is most enlarged. Such cysts attain large size and contain for the most part mucoid material. Examples have even been reported showing that they have attained a capacity of two gallons.

In the mesentery there sometimes develop cysts which are known as *chyle-cysts*, whose sacs appear to be formed of separate mesenteric layers, their cavity being occupied by fluid identical with chyle. Such tumors also sometimes attain great size.

In the eyelids one occasionally meets with cystic dilatations of the lachrymal ducts. These are known as *dacryopic cysts* or *dacryops*. Fistulæ result when they are opened through the skin, and if meddled with at all they should be radically extirpated.

Pseudo-cysts.

In his elaborate work on tumors Sutton has made a distinct classification of pseudo-cysts, which lack some of the characteristics of genuine cysts, yet, nevertheless, are entitled to consideration in this place. Among these are included *intestinal diverticula* and *vesical diverticula*, in either of which instances hernial protrusions of the mucous membrane through the outer coating of the bowel or of the bladder occur, thus

forming pouches. These are common in the bowel, rare in the bladder; especially in the former locality they are often multiple. This condition is often spoken of as *sacculation*, and sacculation of the bladder may even be confounded with true urachus-cyst. They are of little consequence so long as foreign materials, such as fæces, urinary calculi, etc., do not lodge in them.

Pharyngeal diverticula give rise to rare but most interesting tumors. It is well known that the branchial clefts, which in early fœtal life connect with the pharynx, are sometimes not completely closed, and that a portion of one may persist abnormally, giving rise to a condition known as *the pouch of Rathke.* There may also occur sacculation of the pharyngeal wall where it joins the œsophagus, or hernial protrusions, especially in Rosenmüller's fossa.

Cystic dilatation of Rathke's pouch occurs near the upper part of the pharynx, and may attain the size of a marble. Hernial pouches are seldom mistaken for cysts, and are of importance mainly because of the fact that food or other foreign material gathers and lodges in them. Most of the other cystic abnormalities of the pharynx pertain to dermoids, and will be considered shortly. In a general way, these pharyngeal tumors have been grouped as *pharyngoceles.*

Similarly, in the *œsophagus and trachea* hernial protrusions occur, and lesions closely resembling retention-cysts may be met with.

Synovial cysts (*i. e.* those containing synovial fluid) may arise (1) by protrusion of synovial sheaths; (2) by distention of bursæ in the vicinity of joints; or (3) by hernial protrusions of joint membranes. They are often met with in connection with the larger joints, more particularly perhaps about the knee. In this way tumors as large as goose-eggs may be formed, while their location may be so shifted that they present themselves in perplexing ways. To that form produced by hernial protrusion of the lining of a tendon-sheath has been given the name *ganglion.*

The simple ganglion is most often seen on the back of the wrist, and, while it is often only connected with the tendon-sheath, it undoubtedly frequently connects with the synovial membrane of the carpal joints. The compound ganglion, so called, is a much more serious and extensive affair, being one which has prolongations in two or more directions, and usually containing peculiar bodies, known commonly as *melon-seed bodies*, which appear to be fibrinous concretions worn round and smooth by attrition. These are present sometimes in enormous numbers. (*Vide* Tuberculosis of Synovial Structures, Chapter IX.)

Bursæ are normal in many well-known situations in the body, but may undergo cystic dilatation and become annoying tumors. In many other places, under the influence of friction or mechanical irritation, there develop bursæ which are known as *adventitious.* These are sometimes subtendinous, and may communicate alike with joint- and tendon-sheaths. These are true cysts of new formation not developed from a pre-existing cavity.

They are largely the effect of peculiar occupation, as in housemaids and carpet-layers there frequently is formed a *prepatellar bursa*, while miners get them upon the elbow, porters upon the shoulder, plasterers upon the forearm, etc. In the same way, by the pressure of ill-fitting boots, an adventitious bursa is developed over the expanded head of the first metacarpal bone, thus forming a condition known as *bunion.*

Neural Cysts.

This term has been applied by Sutton to pseudo-cystic dilatation of certain cavities found in the brain and central nervous system. *Hydrocephalus* is in one sense a pseudo-cyst of this variety. Quite corresponding to it in fœtal life is *hydramnios.* Hydrocele or cystic dilatation of the fourth ventricle is well known. *Cranial meningoceles*, which are hernial protrusions of brain-membranes, are also pseudo-cysts, to be included in this category, They will be considered at due length in the opening chapter of the Second Volume. *Cephalhæmatoma* might possibly be also included in the same way. *Spina bifida*, a condition to be more minutely described in Volume II., is, nevertheless, practically, a cyst of congenital origin involving the spinal meninges. One form of spina bifida is constituted by cystic dilatation of the central canal of the spinal cord, and produces the condition accurately spoken of as *syringo-myelocele.* (*Vide* Chapters I. and II. Vol. II.)

Sutton has rendered a very great service by showing that the brain and spinal cord are really evolved from a segment of the primary intestine, and that the *intestinal canal and the neural canal communicate in fœtal life* at their *lower terminations;* while it has been shown by several that in the earlier forms of mammalian life they were also connected by their *anterior terminations.* It is in this way that certain complex and rarely met-with tumors of the sacral and coccygeal region are to be explained. So also is the collection of lymphoid tissue in the vault of the pharynx, known as *Luschka's tonsil*, and in the coccygeal region, known as *Luschka's gland*, it being a curious and most instructive fact that lymphoid tissue of this character always is met with in the neighborhood of obsolete canals.

Hydatid Cysts.

Hydatid cysts constitute a distinct class of *pseudo-cysts* due to the *presence of parasites.* In this particular instance it is the ordinary tape-worm (Tænia echinococcus), whose adult form inhabits the intestines of dogs, and whose eggs are conveyed either with food or drink into the alimentary passages of man, where they are hatched, while the embryo, migrating into some distant organ or tissue *viâ* some blood-vessel, gradually becomes transformed into a cyst whose wall has a peculiar structure and which is usually surrounded by a fibrous capsule.

The cyst-wall consists of an elastic outer coat, with a lining layer consisting of granular matter, muscle-tissue, etc., while from it there develop, as the cyst grows, small vesicles, the *brood-capsules* of writers on this subject, containing numbers of *scolices*, which are minute animal heads furnished with sucking disks and a distinct parasitic organization. Hydatid cysts attain sometimes enormous dimensions, and contain within them repetitions of themselves, known as *daughter-cysts.* Occasionally such a cyst fails to reproduce vesicles or brood-capsules, and then is spoken of as *sterile.* Multilocular hydatid cysts also are found. The characteristic hooklets which form a part of the parasitic organism are distinctive and pathognomonic whenever met with. They can be shown by a low power of the microscope. Hydatid disease is very uncommon in this country, but extremely prevalent in certain localities, particularly so in Iceland and Australia.

Cystic Degenerations.

Another term used in connection with many tumors or cystic formations must be defined here. **Hæmatocele** is an expression meaning a tumor composed originally of effused blood which has undergone chemical and other changes, which consist of lamination and thickening of its

exterior portion and fluidification of the interior, until in course of time such an internal blood-clot may be converted into a distinct and plainly walled cyst. This condition is met with especially often in two locations—namely, in the *pelvis* and *between the cranium and the brain*, or in the brain, where distinct and beautiful illustrations are not infrequently met with. As time goes on the hæmoglobin entirely disappears, and the contents of these cysts are translucent or even watery in appearance. Hæmatoceles may form where there has been internal hemorrhage in certain locations which has failed to absorb, and where no pyogenic infection has occurred.

Pseudo-cystic changes occur in many other tumors and in other parts of the body as the result of *mucoid* and *colloid liquefactions*—conditions which are amply described in works on general pathology. Suffice it to say here that in the midst even of apparently dense and entirely defined tumor-masses changes of this kind occur, and lead to formation of cavities containing fluid of variable consistence, causing the tumor when divided to present much the appearance of the geodes or quartz rocks containing cavities lined with quartz crystals. The occurrence of such cystic changes is indicated in naming such a tumor by prefixing the term *cysto-*, as cysto-sarcoma, cysto-fibroma, etc.

2. DERMOIDS.

Dermoids are *cysts or tumors containing tissues and appendages which are developed from the epiblast*, and which occur in situations where skin and mucous membrane are not normally found. The simplest form of dermoid is a cyst whose interior is lined with modified skin, containing sebaceous glands and hair-follicles, from which often numerous long hairs are produced. Even sweat-glands may be present. Its cavity is occupied by mixed material, pultaceous in character, made up of sebum, cholesterine, and growing hairs which are often rolled into balls. The sebum is the product of the glands contained in the cyst-wall.

A more complex form of so-called dermoid cyst is met with, in which we find unstriped muscle-fibre, teeth, mammary glands, etc. These, strictly speaking, belong rather to the class of teratomata, since they contain more or less tissue not of epiblastic origin.

A *dermoid tumor* is one lacking cystic characteristics, made up of tissue largely developed from the epiblast, with more or less tissue of mesoblastic origin. Such a tumor may contain much connective tissue, fat, fœtal hyaline cartilage, and even nerve-tissue, while from its exterior long hair may grow, and teeth may project from its surface or be imbedded within its substance. Such tumors are most often found in the pharynx and about the rectum.

The whole explanation of dermoids and teratomata must be gleaned from embryology, and rests upon the combined arrangement of the different blastodermic layers of the developing ovum and upon the facts already alluded to in explaining Cohnheim's hypothesis of the origin of tumors. Strictly speaking, a *dermoid* should contain only that which may be developed from the *epiblastic* layer. It is well known that teeth and hair, as well as sebaceous material, are epiblastic products. Consequently, such material may be found within a dermoid and call for no further explanation than an epiblastic inclusion, according to Cohnheim's

views. But, so soon as such a tumor contains bone, muscle, nerve-tissue, etc. (*i. e.* tissues of mesoblastic origin) we should, strictly speaking, drop the term *dermoid* and consider it a *teratoma*. Such is the accurate distinction between these two terms.

The most prominent characteristics of dermoid cysts are—First, *skin*, which may be thick or thin, lined with papillæ, containing more or less pigment, its deeper layers possessing a quantity of fat. Second, *hair*, which next to skin is the most constant structure found in dermoids; this may be present in very trifling amount or in long coils or balls. It is of interest that in dermoids found in animals covered with wool we find the same character of hairy structure, while in birds dermoids contain feathers rather than hairs. Third, *sebaceous glands* and their peculiar secretion are almost invariably found. These may be of large size, and sebaceous retention-cysts may be seen in the walls of dermoids. Sometimes *horny* matter or tissue is found in these, indicating the same relation between horn and sebaceous structures as we see upon the external skin in other instances. So, too, material resembling the texture of finger-nails is occasionally found projecting into the cavity.

The fluid or semifluid contents of these cysts consist usually of sebaceous material, cholesterine, epithelial débris, etc. Sometimes it is thick, sometimes thin—sometimes consists almost entirely of mucus.

It is not uncommon to find structures in *ovarian* dermoids closely analogous to, or actually resembling, *mammary glands*. These may be mere nipple-like processes of skin, or completely developed *mammæ*, well formed, but without ducts or gland-tissue, may occupy such a cyst. These really are *pseudo-mammæ*, because they have no ducts. Nevertheless, glandular tissue is not always absent. This resemblance proceeds even further, in that in some of these ovarian mammæ changes occur analogous to those which take place in normal breasts.

The epiblast seems to have the power of developing mammary glands or supernumerary mammæ in most locations—in fact, upon any part of the body-surface. About the thorax they are common; upon the abdomen they are rarely met with; and they have been found even upon the labia.

Sweat-glands are infrequent in dermoids. *Teeth* are quite common. These may vary in number from two or three up to several hundred—may be imbedded in definite sockets or simply sprout from the cyst-wall. Occasionally bone-material lodging such teeth and crudely resembling a jaw will be found.

Dermoids containing *mucous membrane* are found, especially in connection with the ovary and with the post-anal gut (*i. e.* the original passage communicating between the spinal and alimentary canals).

It is curious that under these circumstances mucous membrane is sometimes furnished with hair, as it normally is in the stomach or other cavities of some of the lower animals. Mucous glands and retention-cysts of these glands are also found in ovarian dermoids. This will be much more readily understood if the mutability of skin and mucous membrane be not forgotten. The transition from one to the other is not difficult, and we find all intermediate stages between the two extremes—if not in man, at least in the animals. This will account also for the fact that skin-covered dermoid tumors are found in certain parts of the alimentary canal, and particularly in the pharynx. These tumors grow also from the mucous membrane of the bowel, of the rectum, or even of the small intestine.

Sutton has made a happy division of dermoids into three classes:

1. *Sequestration.*
2. *Ovarian.*
3. *Tubulo-dermoids.*

1. **Sequestration dermoids** occur chiefly in situations where during embryonic life coalescence takes place between two surfaces possessing

an epiblastic covering, although sometimes this coalescence practically occurs late in life and by implantation.

Dermoids of the trunks occur particularly where opposite halves of the body-wall coalesce—that is, in the mid-line of the trunk and head. Dermoid cysts are found rarely in connection with *spina bifida*, and certain tumors spoken of as spina bifida undoubtedly are, in effect, dermoids. Anteriorly, dermoids occur frequently in the scrotum, possibly occasionally in the testicles. At the umbilicus they are rarely met with—usually as pedunculated tumors projecting externally. In the mid-line of the thorax and neck they are most common opposite the manubrium, dropping down behind it to invade the anterior mediastinum. Near the hyoid bone they occur relatively frequently; about the head they are met with most commonly at the angles of the orbits—more so at the outer than the inner angle. Dermoid cysts are known to oculists as growing upon the iris or springing from the conjunctiva. About the ear they are not infrequent; in the roof of the mouth, especially when this be incomplete, we frequently find cysts of epiblastic origin.

Sequestration dermoid cysts are also undoubtedly found in connection with the *dura mater*, in the scalp, most commonly at the anterior fontanelle, at the root of the nose, and at the external occipital protuberance, where they may be confounded with sebaceous cysts or with meningoceles. In order that a dermoid of the dura may communicate with the skin there must of course be osseous defect.

Sequestration dermoids upon the limbs have been mostly reported as sebaceous cysts. They are rare, and usually associated with antecedent injury, by which epiblastic structures are driven in and implanted in such a way that as they develop they give rise to these peculiar tumors. These are what Sutton speaks of as *implantation dermoids*. They have been met with upon the fingers and elsewhere.

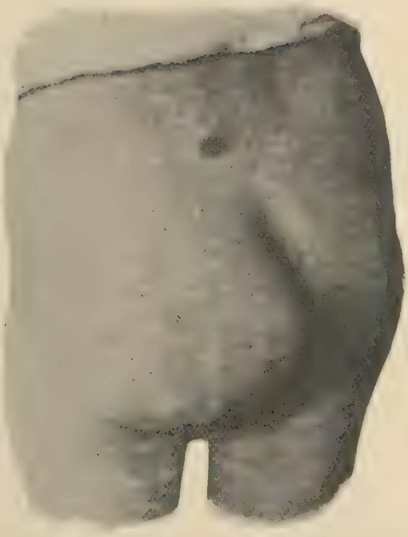
Tubulo-dermoids.—These are largely connected with obsolete canals and ducts. It is a great service which Sutton has rendered us in proving, apparently beyond the possibility of doubt, that the central canal of the nervous system is really of intestinal origin, and may be regarded as a disused segment of the primary alimentary canal. He has shown also how it behaves occasionally as do other functionless ducts, and that cysts and dermoids in connection with it are to be thus, and thus only, explained. He and others have also shown the anterior as well as the posterior communication of these canals, and the pituitary body is to be regarded in this light as the same formation of lymphoid tissue around an obsolete canal which we see in Luschka's tonsil close by, and in Luschka's gland at the other extreme of the canal.

The primary alimentary canal, then, was a continuous tube lined with a continuous layer of columnar epithelium. That portion connected with the yolk-sac develops into the intestine, the balance into the central nervous canal. Portions of this canal are in post-natal life absolutely obsolete; others persist in a very rudimentary condition. Dermoid cysts and dermoid tumors develop in connection with each of these. In some of these there is a large central cavity; others are almost absolutely solid. Thus we meet with dermoids in the coccygeal region which have been variously regarded as sarcomata, adenomata, etc., which are really of origin as stated above, and which should be considered simply as dermoid tumors. Most of these project outwardly; some of them arise and develop within the pelvis. Dermoid cysts and tumors are also met with in connection with the rectum—sometimes between the rectum and the bladder, sometimes between the rectum and the spine. Dermoid tumors are also found in connection with the pituitary body. These sometimes develop within the cranium, or, again, protrude perhaps into the orbit, perhaps into the pharynx.

Thyroid dermoids are tumors of very great interest. They develop sometimes about the cranio-pharyngeal canal, which may be detected as a small canal in the macerated sphenoid bone of a fœtus, and which before birth is filled with fibrous tissue. It connects with a recess in the middle line and at the base of the skull, presenting in the pharynx, which is often spoken of as the *bursa pharyngea*. It is around this recess that the lymphoid tissue known as "the pharyngeal tonsil"

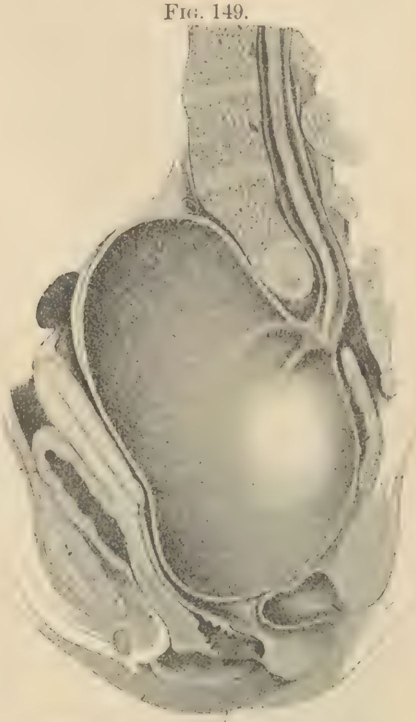
develops. It may thus be expected that the roof of the pharynx should be the occasional site of dermoids. It is from the pharynx or the floor of the mouth that in vertebrata the thyroid body arises. In higher forms it becomes dissociated from the pharynx and shifts its position. The thyroid body is developed around the thyroid duct, which first appears as the thyro-hyoid duct, which later becomes divided, that portion in relation with the tongue becoming the thyro-lingual duct, the remaining portion persisting as the thyroid duct. These are present about once in every ten subjects, according to Sutton, the canal when persistent being lined with epithelium. When the extremities of these ducts become occluded, we may

FIG. 148.



Solid tumor escaping from pelvis (original).

FIG. 149.



Congenital dermoid cyst of pelvis (Ahlfeld).

have retention-cysts. In the same way dermoids of the tongue are formed, similar to those occurring on the scalp. These are frequently mistaken for sebaceous cysts. They may be unilateral, central, or even bilateral. The *lingual* duct is also of interest, because it would appear that certain cases of epithelioma of the tongue arise along this duct, and perforating malignant ulcer of the tongue is thus produced. Dermoid tumors of the lingual or thyroid ducts resemble in structure the thyroid body. The thyroid duct may also be detected in many adults running from the isthmus of the thyroid body to the posterior aspect of the hyoid bone, and surrounded by muscle-tissue. Sometimes the space usually occupied by this duct is represented by a series of detached bodies known as *accessory thyroids*. These are not infrequently the seat of cysts, sometimes of considerable size. (The accessory thyroids often enlarge when the main thyroid has been extirpated for disease.) Thus cysts in close relation to the hyoid bone are common. Some of them grow slowly; others, rapidly and contain much fluid. Many of them are unilateral, and are often mistaken for enlargements of one lobe of the thyroid. Cysts growing from accessory thyroids are often filled with papillomatous masses, and are occasionally the seat of malignant degeneration.

In the *omphalo-mesenteric* duct or its remains, especially in relation with the umbilicus, we often meet with small cysts or tumors in infants and young children.

When the duct is persistent it presents normal intestinal structure, and, like the appendix, possesses much adenoid or lymphoid tissue.

Another and very important form of *tubulo-dermoids* develops in connection with the *branchial clefts* of the neck. Congenital fistulæ of the neck have been long known, but only comparatively recently understood. Of the branchial clefts, it is well known that the first alone should persist, as the Eustachian tube, etc. Occasionally, however, they fail to become completely obliterated, and then we have congenital tumors or cysts, which may, however, not develop to appreciable size until somewhat late in life; or we may have fistulous passages opening either into the pharynx or externally, forming canals varying in length from half an inch to two inches, secreting a little fluid because lined with epithelium. When these become inflamed an abscess results. When they open externally the opening is often marked by a little tag of skin containing a fragment of yellow cartilage. These are often spoken of as *cervical auricles*. They open usually along the line of the sterno-mastoid muscle. The internal openings of these fistulæ frequently form diverticula from the pharynx or œsophagus. Thus it will be seen that dermoid cysts about the neck are, for the most part, relics of openings or ducts which are normal in embryonic life, but which should have been obliterated at or long before birth. Congenital fistulæ, however, may be met with in the middle line of the neck which are not to be confounded with branchial fistulæ, but rather with the ducts previously described.

Ovarian Dermoids.—These may be unilocular or multilocular cysts, usually the latter. They are lined with epithelium, and contain for the most part mucoid fluid, the inner coat being practically identical with mucous membrane. Occasionally, however, we meet with skin furnished with hair, sebaceous glands, teeth, and even nipples. The multilocular cysts are practically an aggregation of those just described. They are surrounded by dense capsules, often attain great dimensions, and are made up of primary cysts resembling large cavities in a honeycombed-like mass, which itself is occupied by secondary cysts, and belong rather to the class of mucous retention-cysts; and these are occupied by still smaller ones which are histologically indistinguishable from distended ovarian follicles. In these large tumors we find in some cases hair, in others teeth, in yet others sebaceous glands, etc., the dermoid constituents being scattered throughout.

FIG. 150.

Ovarian dermoid, showing ball of hair (original).

3. TERATOMATA.

So far, I have endeavored to limit the term *dermoid* to tumors which are essentially of *epiblastic* formation, which, nevertheless, may be present in deep situations, their location here to be explained on the inclusion theory of Cohnheim. There is next to be dealt with a still more complicated type of tumor, composed of tissues of both *epiblastic and mesoblastic* origin, perhaps even *hypoblastic*, whose structure is too complicated to be taken up at length in this place. Their consideration belongs rather to that department of pathology known as *Teratology*, which is

supposed to deal especially with monsters. Strictly speaking, a *teratoma* refers to an irregular tumor or mass containing tissues and fragments of viscera of a suppressed fœtus which is attached to an otherwise normal individual. Nevertheless, the term is often applied to growths which are the result of luxuriant mesoblastic development in which yet neither form nor member of a suppressed fœtus is present.

As between exaggerated mesoblastic growth in this direction, which supposes the presence of a single ovum or the presence of supernumerary members, even to the extent of conjoined twins, which presupposes two distinct embryos, one of which goes on to complete development, while only certain parts of its companion develop, we cannot stop here to go into minutiæ. The presence of supernumerary members is largely connected with what is called *dichotomy*, alluding thereby to cleavage either at the anterior or posterior end of the developing embryo. *When the whole embryonic axis divides twins may be produced*, but should cleavage be partial we may have a monster with two heads if it be anterior, or if it be posterior with three or more limbs. Children born with these deformities are usually spoken of as *monsters*, and the study of such cases belongs entirely to teratology. But in certain tumors small portions of a suppressed fœtus may develop, as, for instance, from the posterior portion of the sacrum, or within the abdomen or thorax, or upon the neck or face, which on dissection may contain a few vertebræ or processes resembling fingers, associated perhaps with a structure resembling intestine or liver. This is what should be spoken of as a true teratoma. Such tumors possess for the pathologist the greatest value, In surgery, however, they are rare, and there are scarcely two cases alike. The question of operation will often come up, as it does with supernumerary limbs, and each case must be studied and decided purely upon its own merits. Sometimes they are amenable to extirpation.

Teratomatous tumors are sometimes found hanging in the pharynx, attached by a small pedicle. In this location they are likely to be confounded with dermoids unless carefully examined after removal. Many instances of this type of tumor are met with in animals. Here no false sentiment will prevent complete examination and preservation of the specimen. (For further information, however, the reader must be referred to the large works on Teratology or to works like those of Sutton on *Tumors.*)

4. TUMORS OF IMMATURE MESOBLASTIC-TISSUE TYPE.

SARCOMA.

To these the now well-defined and perfectly understood name of *Sarcoma* is given. In times past this name, which simply implies a fleshy tumor, has been made to cover many different conditions, and the reader of literature of forty years or more ago may be much misled by the use of this term in many significations. To-day *sarcoma means a tumor composed of immature mesoblastic or embryonic tissue in which cells predominate over intercellular material.* Sarcomata are sometimes encapsulated: they merge into and infiltrate the surrounding tissue and disseminate widely, and for the most part have these propensities and characteristics to such a degree as to constitute malignancy. For the laity sarcomata and carcinomata are together included in the comprehensive term of *cancer;* for us they may constitute but one form of cancer. Sarcomata are classified, according to the shape of their cells and their disposition, into—

A. *Round-celled,*
B. *Spindle-celled,*

C. *Myeloid*,
D. *Alveolar*, and
E. *Melano-sarcoma*.

A variety of the round-celled sarcomata is also distinguished as *lympho-sarcoma*.

FIG. 151.

Small round-cell sarcoma of thigh (× ½″; Spencer).

A. Round-celled Sarcoma.—This is simple in construction, and consists of round cells containing very little intercellular substance. The nuclei of the tumor-cells stain easily, the cells themselves varying very much in size in different cases. Blood-vessels lead up to the tumor, but in the interior appear rather as channels. These tumors have no lymphatics: they grow rapidly, infiltrate easily, recur quickly, and give rise to numerous metastatic or secondary deposits. They may affect any part of the human body. The size of the cells is supposed to be in some measure an index of their malignancy—the smaller the cell the more malignant the tumor. They appear at all periods of life. They are perhaps the most commonly met with of malignant tumors in animals.

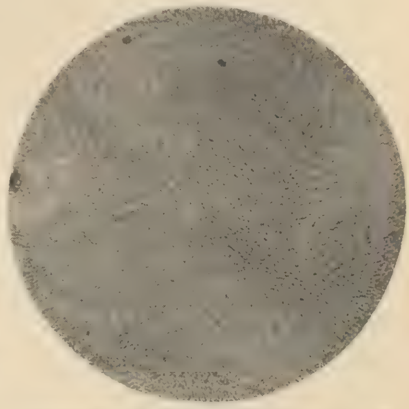
FIG. 152.

Recurring sarcoma of parotid (original).

Lympho-sarcoma.—This is composed of cells similar to the previous form, but enclosed in a delicate meshwork resembling that of lymph-nodes, hence the term *lympho-sarcoma*. Lympho-sarcomata are not to be confounded with enlargements nor with the specific granulomata involving these lymphatic structures.

B. **Spindle-celled Sarcoma.**—In this form the cells have a spindle shape and run in all directions, so that sections will show them in various shapes and sizes. In some cases the cells are very small and slender, in others very large. Here, again, the size of the cell is a measure of the malignancy of the tumor.

Fig. 153.



Spindle-cell sarcoma of thyroid (× 1/6″; Spencer).

The largest type of these spindle-cells is frequently striated transversely like voluntary muscle-fibre, and tumors composed of this form have been considered as tumors of striped muscle-tissue, and have usually been called *rhabdomyoma*. Strictly speaking, there is no tumor of striped muscle-fibre, and the rhabdomyomata of writers generally must be considered as spindle-celled sarcoma or may be dignified by the name *myosarcoma*. In these growths also one occasionally meets with immature cartilage, sometimes even to such an extent that they are regarded as cartilaginous rather than sarcomatous, this cartilage frequently calcifying, sometimes even ossifying. The sarcomatous (*i. e.* the malignant) character of these tumors is clinically demonstrated, if not microscopically betokened, by the frequency with which they recur after removal. In certain spindle-celled sarcomata, however, the cells sometimes undergo conversion into fibrous tissue, and may then be spoken of as *fibro-sarcoma* or *fibrifying sarcoma*.

Fig. 154.

Sarcoma of femur following fracture—*i. e.* developing in callus (original).

C. **Myeloid or Giant-celled Sarcoma.**—In this form the tissue resembles histologically the red marrow of young and growing bone,

containing large numbers of multinuclear cells imbedded in a matrix of spindle- or round cells. These tumors, for the most part, occur in the long bones, and when freshly cut look much like a piece of liver.

Giant or multinuclear cells should be present in relatively considerable numbers to entitle a tumor to classification in this group. When round, spindle-, or giant cells mingle in nearly equal proportion, the tumor should be spoken of as a *mixed-cell sarcoma.*

D. Alveolar Sarcoma.—This is a rare form, in which the cells, contrary to the general rule of sarcomata, assume an alveolar arrangement strongly imitating that of epithelial cells in carcinoma. Almost invariably, however, on minute examination it will be possible to distinguish a delicate reticulum between individual cells, which is never met with in cancer. By some the alveolar sarcomata are grouped as belonging to endotheliomata (*q. v.*). On this point we need further light. Their common situation is in the skin, especially in connection with congenital defects, such as hairy and pigmented moles.

E. Melano-sarcoma, *sometimes known as Melanoma.*—This refers to the deposition of pigment, rather than to type or shape of cell, the distinguishing feature of these growths being the presence both in the cells and in the intercellular substance of a variable quantity of blackish pigment. Of all the forms, the melanotic growths are generally con-

FIG. 155.

Melanotic sarcoma of back (contributed by Dr. Holloway).

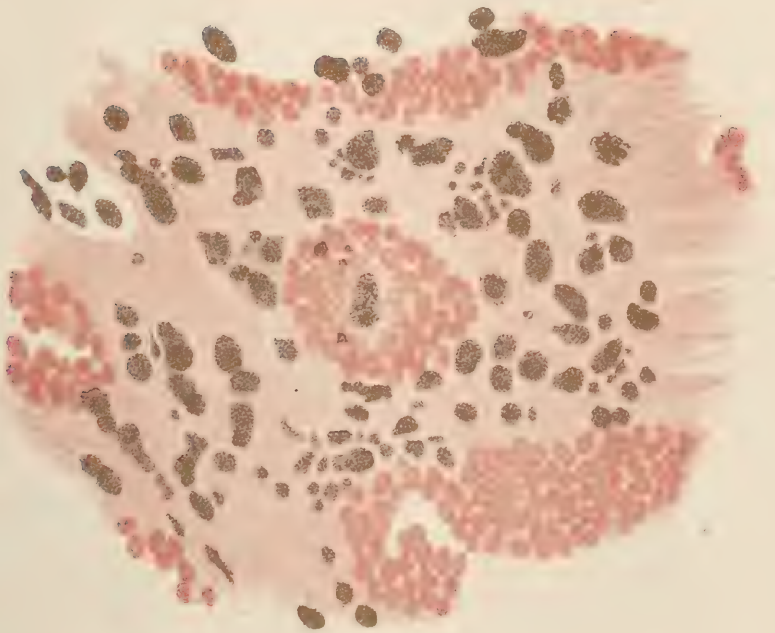
FIG. 156.

Melanotic sarcoma of liver (secondary) (× ½″; Spencer).

sidered the most malignant. They invariably recur after removal, they lead to secondary deposits at long distances, and they present the most intractable and incurable form of cancer. Deposition of pigment in carcinomata is most rare, if ever met with, and the growths heretofore spoken of as melanotic cancer should be relegated entirely to the class just under consideration. (*Vide* Plate XIII.)

General Characteristics of Sarcomata.—The vascular supply of sarcomata varies within wide limits. In nearly all instances it is of capillary character, the blood circulating rather through vessels with well-marked walls. While large vessels may be found about and in the periphery of these tumors, distinct vascular structure is usually absent

PLATE XIII.

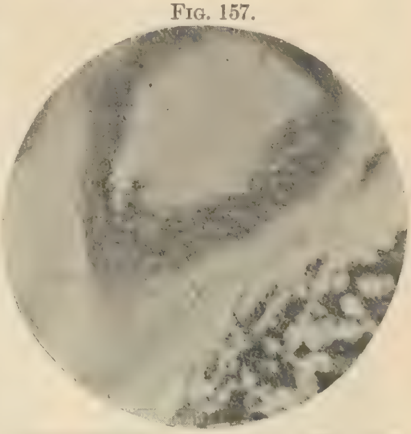


Melano-Sarcoma of Skin; *a*, Stroma with Pigment Cells; *b*, Endothelial Cell Nests with Migrated Pigment Cells. (Klebs.)

from the more internal vessels; all of which will explain the frequency of hemorrhage, its persistency after operation, and the ease with which large extravasations occur. True hæmatocele may thus take place within sarcomatous tumors with the usual later cystic alterations, and thus in one way we have the condition frequently spoken of as *cysto-sarcoma*.

In attacking these growths the most vascular and bloody area may be met with just about their margins, the blood-vessels expanding as they arrive at the tumor, and bleeding sometimes furiously. Under most circumstances, however, this hemorrhage can be controlled by packing or by operating at a little greater distance from the circumference of the growth.

FIG. 157.



Angeio sarcoma: blood-vessel with coagulated blood (× ¼"; Spencer).

Metastasis in sarcoma is common, dissemination occurring mainly along the veins, since these growths often penetrate into the venous channels and permit of easy detachment of fragments, which are then carried along as emboli. These emboli pass naturally to the right side of the heart, and thence to the lungs, where it is most common to find secondary growths, except in areas emptying into the *portal* veins, in which case the *liver* will be the most common site. Sarcomata are destitute of lymphatics, and dissemination does not occur through these channels.

Infiltration is also a common phenomenon with these growths. This is perhaps most often seen in muscular tissue, particularly with growths proceeding from the periosteum and projecting into it.

Sarcomata, like other tumors, tend to grow along the lines of least resistance. Hence processes of these tumors will insinuate themselves into fissures and interspaces, and penetrate perhaps even into the cavities, from which it is hazardous or impossible to remove them. Thus, sarcomata springing from the head of a rib have been known to extend through an intervertebral foramen and give rise to an intraspinal tumor, causing fatal pressure.

Secondary changes are commonly met with in sarcomata, the most frequent being *hemorrhage*. *Myxomatous degeneration* is also frequent, and gives rise to *cystic* conditions. *Calcification* is common, particularly in the more slowly-growing tumors which arise from bone. Upon the other hand, *necrosis* (*i. e.* ulceration) is common in growths which project upon the surface or into any of the open cavities of the body. Ulceration here is simply an expression of growth at a rate relatively faster than the possibilities of nutrition permit, and gangrene is to be regarded as a failure to supply sufficient blood. It may also mean infection, of which it is, indeed, a usual expression.

Tumors of this character, which luxuriate upon reaching the surface, and which bleed easily upon the slightest touch, were known in time past as *fungus hæmatodes*. The name may be preserved for the sake of convenience, but should be held to mean in almost every instance a rapidly-growing, round-celled sarcoma.

In *bone* these tumors may arise centrally (*i.e.* in the marrow-cavity) or may spring from the periosteum. The former variety rarely affects the adjacent lymph-nodes. Myeloid tumors are practically always central. Tumors located thus centrally always expand the bone, sometimes to enormous dimensions. Periosteal sarcomata are never myeloid, always round- or spindle-celled, and are more liable to calcification, or even to ossification, than central tumors. Sarcomata arise in the follicles of the teeth, but only in children, and are particularly apt to involve the bone about the first permanent molar (Sutton). The jaws are very apt to become involved in growths springing from adjacent parts, particularly from the nasopharynx and the nasal fossæ. From the vault of the pharynx spindle-celled growths are often seen growing, projecting down into the parts beneath, plugging one or both nasal fossæ and impeding both respiration and deglutition. These basal growths also penetrate upward and invade the cranial cavity.

In the *eye* sarcomata are common and produce hideous pictures of malignant disease, which were formerly spoken of as *medullary* or *encephaloid* tumors or as fungus hæmatodes. Sarcoma of the eye almost invariably recurs after removal,

FIG. 158.

Sarcoma of antrum and jaw (original). (Fatal in two months from commencement.)

FIG. 159.

Cystic osteo-sarcoma of pelvis (contributed by Dr. Holloway).

and the prognosis in all such cases is bad. In the *salivary glands* sarcomata are common, particularly in the parotid. In these growths secondary changes are quite common, and a mixture of cartilaginous development and cystic degeneration is frequently seen.

The *testicle* is quite prone to sarcomatous infection. Lympho-sarcoma is occasionally seen here. The spindle-celled variety attacks only one of these organs at a time, and in many instances these growths contain so much cartilage as to have been considered in time past as enchondromata. Sarcoma of the *ovary* is not less common, both organs being sometimes simultaneously affected. The disease is most common in early life—is seldom seen after fifteen years of age.

The *mammary gland* is not infrequently the seat of sarcoma, which originates in the connective tissue of the breast, entangles the secreting structure, and, when seen in microscopical sections in which the ducts are cut across, is *frequently mistaken for adenoma*, because of the duct-spaces which are lined with epithelium. Nearly all of these tumors recur quickly after removal, and especially in nursing women they grow with great rapidity.

Lympho-sarcoma is most common in the posterior mediastinum, and constitutes a rapidly-growing tumor which quickly encroaches upon the important thoracic organs and viscera. Interference with venous circulation because of less resistant walls is almost always evident. The important nerve-trunks of the part are often involved, and illustrations of pressure upon the pneumogastric are usually not wanting. In the *abdomen* lympho-sarcoma arises usually in the connective tissue

posterior to the peritoneum, again involving vessels and nerves in the same way as before. In the ring of lymphoid tissue which surrounds the upper end of the œsophagus, of which the *tonsils* are the most conspicuous features, lympho-sarcoma is also quite common. In other words, in and about the tongue and the larynx we meet with many growths of this character.

The deposition of *pigment*, and in particular its expression of malignancy, are the most interesting features of these growths. Deposit of pigment is normal in certain locations, and in certain races is extensive. The amount of pigment in the uveal tract usually compares closely with that in the skin. Excessive development of pigment is much more rare than excessive lack of it—that is, *albinism* is much more common than *melanism*. Pathological pigmentation is found usually in connection with tumors, either in the skin or within the eyeball. Melanotic sarcomata contain variable amounts of pigment, the particles of pigment being found not only in the proper cells of the tumor, but even in the walls of its blood-vessels. It is singular that the secondary growths frequently contain more of this material than the primary, which may almost entirely lack it. In the *skin* we most commonly meet with melano-sarcoma as arising either from *pigmented moles* or from the *matrix of a nail*. In the former case the cells are collected in alveoli, and the general type of the tumor is of the alveolar sarcoma. Pigmented moles do not necessarily undergo this change, but are always sources of danger. *Melanosis* occurring in connection with the tips of the fingers or toes should always be viewed with the greatest apprehension, and should lead to prompt amputation of the member. In the *eye* melano-sarcoma occurs usually in the uveal tract. So far as I know, these intraocular tumors invariably recur after surgical attack. It has been shown that melano-carcinoma rarely occurs in the ciliary body of the eye, but, as stated above, almost all melanotic tumors belong to the sarcomata.

Sarcoma is common in the lower animals, particularly so in horses—most common in those of gray color. It is met with also in cows and various other domestic and undomesticated animals.

Glioma.

Glioma, by some regarded as a variety of sarcoma, is by others (*e. g.* Sutton) considered as a distinct variety of tumor. Inasmuch as the nervous system is really of epiblastic origin, it is questionable whether gliomata may, after all, belong in Group VII., Tumors of Epithelial or Hypoblastic Origin. For purposes of simplification, at least, it may be well included here as a type of sarcoma. It consists of *delicate connective tissue, identical with that which is known in the histology of the nervous system as neuroglia*. It bears the same relation to the central nervous system that plexiform neuroma bears to peripheral nerves. It occurs only in the former—that is, in the *brain*, in the *spinal cord*, and perhaps in the *optic nerve*. Structurally, it consists of cells with delicate ramifying processes held in place by fibrous tissue. Gliomata are usually quite vascular, the vessels being even sometimes sacculated. For the most part these tumors are solitary—*i. e.* do not give rise to secondary deposits. When near the surface of the cortex such a tumor may appear like an enormous convolution (Virchow). In the basal portions of the brain these tumors may attain considerable size.

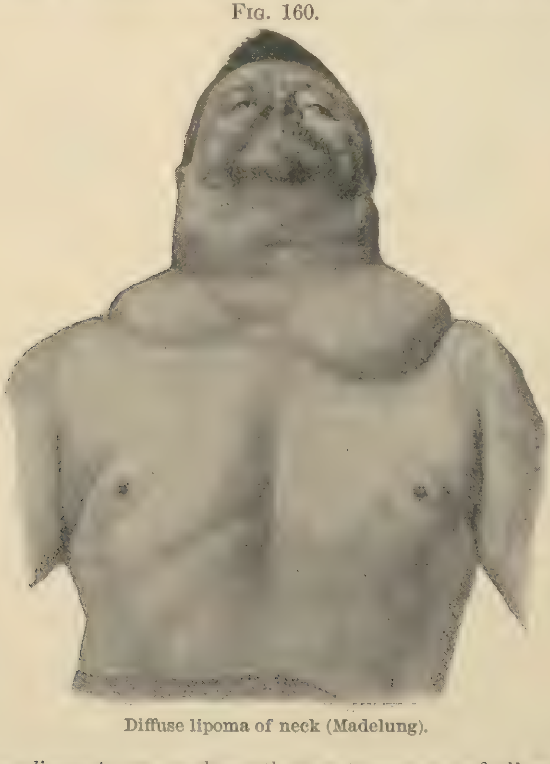
Gliomata in the *spinal cord* are rare, occurring twenty times as often in the brain as in the cord. In the latter location they are usually indistinctly outlined and cause a general enlargement of the cord. They may occur anywhere along its length, but are most common in the cervical portion. They are most common also between the fifteenth and thirtieth years of life, but may be met with in old age. The symptoms of these growths consist usually of pressure-effects, and it is ordinarily impossible to diagnose them before either operation or autopsy. If attacked at all, they need to be most radically extirpated, else these, like sarcomata in general, are most prone to return.

5. TUMORS OF SIMPLE MESOBLASTIC-TISSUE TYPE.

Lipoma.

Lipomata, or tumors composed of fat, are the most commonly met with of all neoplasms. Their normal type is the *ordinary adipose tissue* of the body, while, anatomically, they may be divided into the *encapsulated* and the *diffuse*, the former of which are surrounded by more or less of an investment of fibrous tissue by which a certain form and integrity are preserved. The diffuse lipomata are those which are possessed of no capsule, where the pathological collection of fat merges into that normally present—in other words, they are not circumscribed.

Fig. 160.



Diffuse lipoma of neck (Madelung).

Subcutaneous lipomata are perhaps the most common of all, and are usually irregularly lobulated and encapsulated, adherent rather to the skin than to the

deeper tissues. Usually but one is found in a given individual, though instances of multiple lipomata are not rare. They develop sometimes to enormous size, cases being on record where the tumor has even weighed one hundred pounds. They may be met with at any point on the surface of the body. The lobules often burrow between the muscles, and those found in the palm of the hand penetrate even beneath the palmar fasciæ. They are sometimes markedly pedunculated, and hang often by a small stem. The diffuse subcutaneous lipoma is most common about the neck; next most common in the groin and axilla.

Subserous lipomata are for the most part retroperitoneal, and very large tumors of this character, mistaken for ovarian tumors, have been successfully removed by operation. In the hernial canals and spaces they also are met with. They develop, moreover, beneath the peritoneum covering the intestines, and in this location they give rise occasionally to *intussusception.* Here they have the general form and significance of *appendices epiploicæ* in their pathological development.

Subsynovial lipomata occur about various joints and tendon-sheaths; especially within the knee they assume a distinctive type which has been called *lipoma arborescens,* where they take on a dendritic appearance and arrangement. *Submucous* lipomata are rare. *Intermuscular* fatty tumors are occasionally met with, an interesting variety being that which develops between the masseter and buccinator muscles. *Intramuscular* forms are also rarely met with, as well as a variety known as *parosteal,* which arise in connection with the periosteum. Fatty tumors also occur within the spinal dura, as well as outside of it within the spinal canal, and more or less lipomatous alterations are common in connection with spina bifida.

Lipomata are ordinarily easy of recognition, save when deeply located. The subcutaneous forms are intimately related with the overlying skin, and have a dough-like consistence which is usually pathognomonic. Those tumors, suspected to be fatty, which are met with in the middle line of the back or cranium are always to be viewed with suspicion, since they are often connected with congenital meningeal protrusions.

An encapsulated lipoma, when thoroughly removed, will not return. It is when one deals with the diffuse variety that he often finds interference unsatisfactory or regrets that he has attempted it, the difficulty being in knowing where to stop.

Mixed forms of fibrous and fatty neoplasm are not infrequently met with, which may be spoken of as *lipoma fibromatosum* or *fibroma lipomatosum* according as one or the other tissue predominates. These growths are innocent in their character, but call for thorough extirpation. They frequently give rise to considerable discomfort or pain—so much so that they have been spoken of as *lipoma dolorosa.*

Fibroma.

Fibromata are tumors composed of fibrous tissue, which, when of pure type, are found to be not so common as was formerly supposed, the majority of tumors hitherto roughly grouped as fibromata containing either muscle-tissue or sarcomatous elements, which takes them out of the category of pure fibroma. A typical fibroma is ordinarily dense, and is composed of wavy bundles of fibrous tissue whose cells are long and slender and closely packed together, the mass being permeated by distinct blood-vessels.

Fibroma occurs most commonly in the *ovary,* the *uterus,* the *intestine,* the *gum* (epulis), in *nerve-sheaths,* and in the *skin* in the form of so-called *painful subcutaneous tubercles* and *molluscum fibrosum.* There is also a fibrous tumor of the skin, known as *keloid,* sustaining to fibroma the same relation that obtains between exostosis and osteoma.

The *painful subcutaneous tubercle* of many writers is a sample of pure fibroma in the shape of a small, flattened pea-like tumor which never attains great size. It is situated loosely in the subcutaneous structure and may form a visible prominence. Insignificant as it would thus appear, it becomes the seat of exasperating pain, particularly when touched or handled: this may radiate to considerable distances. The etiology of these little growths is absolutely unknown.

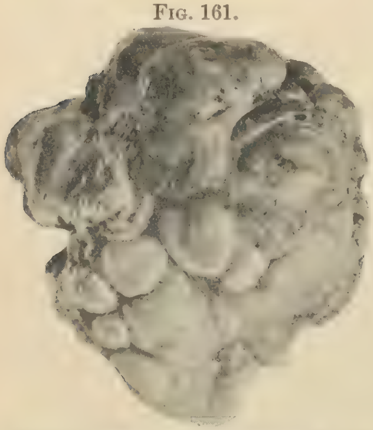
In the ovary, the uterus, the intestine, and the larynx pure fibrous tumors are pathological curiosities rather than common lesions.

Epulis means, in effect, any tumor growing upon the gum. The term was formerly applied in an indistinct and too comprehensive way, although it is still retained in literature. But pure fibromata do spring from the fibro-osseous structure of the gum and alveolar process. They are covered with the gingival mucous membrane and seem to spring from the periodontal membrane. They seldom attain large size; then only through neglect. By the pressure of such tumors teeth may be separated and no little distortion of the mouth produced.

Molluscum fibrosum has also been described as *dermatolysis* and *pachydermatocele*. It consists essentially in hypertrophy of the fibrous elements of the body-covering, which may affect a small area like the scalp or a large area of integument which is made to hang in folds. It may also assume the form of scattered nodules, varying in size. It may be associated with true fibroma of nerve-sheaths or with true neuroma. It is seldom observed in this country, and is for the most part confined to the African races.

Keloid is a fibrous neoplasm arising, for the most part, in cicatricial tissue, which is essentially fibroid in structure. It is a neoplasm which often follows the general outline of the scar in which it grows, consists in elevation of the surface, ordinarily quite smooth, sometimes of a delicate pink from the dilated vessels which it contains. Keloid is the *bête noir* of surgeons, since it frequently complicates and disfigures scars which have been at first perfectly satisfactory, and since it indicates a condition which it is discouraging to deal with, because when it is removed there is usually recurrence of growth within a few months after cicatrization. It occurs often in stitch-hole scars and upon the site of extensive burns, may be met with after puncture of the ears for ear-rings, and has also been observed in scars left by smallpox, acne, etc. It is more prevalent in the colored than in the white race. In negroes multiple keloid tumors are often seen, occasionally even in large numbers. Their explanation is unknown, and it may be that some trifling injury has preceded each individual tumor. *Vide* Plate XIV.

Fig. 161.



Enchondroma from inner aspect of pelvis (contributed by Dr. Holloway).

Chondroma.

The true **chondroma** is a tumor *composed of hyaline cartilage.* It occurs most often and typically in the long bones, usually in relation with epiphyseal cartilages, and, consequently, is most often noted during the earlier years of life. While it is usually a solitary tumor, multiple chondromata are often seen, especially upon the hands. These tumors are often encapsulated, and form deep hollows in which they rest.

PLATE XIV.

Keloid of External Ear; *a*, Dense Tissue of Skin; *b*, Fibrous Connective Tissue; *c*, Epidermis. (Klebs.)

Unless pressing upon nerve-trunks they are painless and slow of growth. They are exceedingly dense and hard, and ordinarily immovable. *Mucoid softening* (*i. e. cystic degeneration*) is common, and the softened areas may give rise to fluctuation. There may be coincident *calcification* or *ossification* in any of these growths. It is noted as a curious circumstance, by Sutton, that their tissue resembles histologi-

Fig. 162.

Multiple enchondromata (contributed by Dr. Holloway).

cally the bluish, translucent epiphyseal cartilage which is seen in progressive rickets.

To the small local hypertrophies of cartilage which are seen especially about joints, about the laryngeal cartilages and the triangular cartilage of the nose, are given the term *ecchondroses.* They are most common in the knee in connection with rheumatoid arthritis, and occur as prominences along the margins of the joint-cartilage. They may project to such an extent as to be detached by accident, after which they become movable and floating bodies in the joints. Many of the floating cartilages or bodies found in joints are, in other words, detached ecchondroses,

which may be smoothed off by attrition, and which may be found singly or multiple, even several hundred existing in one joint.

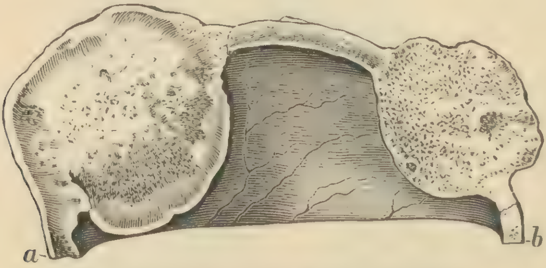
Chondromatous changes as occurring in *sarcomatous tumors* have already been alluded to. It seems to be easy for connective tissue to form hyaline cartilage, and mixed tumors may thus be met with in connection either with sarcoma, fibroma, or other forms.

The TREATMENT of chondroma is solely operative. Unless the integrity of a member or a limb be compromised, such a tumor can usually be shelled out from its location, but requires that the matrix be completely extirpated; all of which may call for the use of powerful bone-instruments. At other times *amputation* is the only measure which may relieve from deformity, pain, and disability. The *ecchondroses* occurring within joints call usually for incision and evacuation with the most rigid aseptic precautions, without drainage, as the case may be; when practised according to modern technique this is almost invariably successful. In former times many lives were lost because of septic infection, which is now avoidable.

OSTEOMA.

Under the head of Nomenclature I have already endeavored to distinguish as between **exostosis**, or irregular bone-outgrowth, and **osteoma**, as a distinct tumor which is composed of bone-tissue, with the subvariety **odontoma**, or tumors of dental origin and structure. Osteoma is regarded by some as ossifying chondroma, since it is nearly

FIG. 163.



Double osteoma of skull (Musée Dupuytren).

always found near epiphyseal lines, and is always covered by hyaline cartilage when thus found. Nevertheless, it is not invariably such. We speak of *compact* or *ivory* osteoma and of a *cancellous* form. The former is identical with the compact tissue of the shafts of long bones, and may occur anywhere, but is most common about the cranium, at the frontal sinus, the external meatus, and the mastoid process. Osteomata growing into the frontal sinus of oxen, for instance, form large lobulated bony masses, sometimes weighing several pounds and as dense as ivory. Some of these tumors growing into the cranial cavity have been absurdly regarded as ossified brains. Osteomata in connection with the external auditory meatus partially or completely obscure this channel and cause deafness. They constitute *ivory*-like growths, which defy sometimes the finest steel instruments with which the surgeon can supply himself.

Cancellous osteomata grow in the cranium as well as in the long bones, and, like the compact forms, only occasion pain by pressure upon nerve-trunks.

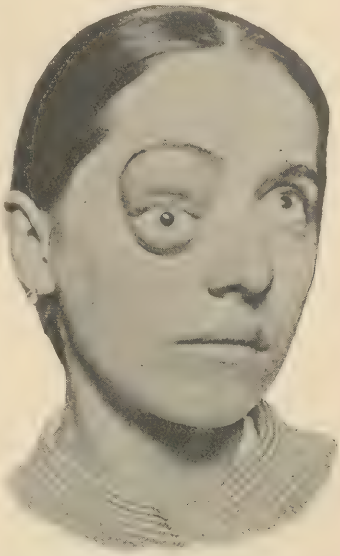
Exostoses are classed by Sutton as—

(1) Those formed by *ossification of tendons* and their attachments. One should exclude from this group such natural or evolutionary processes as the superior condyloid process, the third trochanter of the femur, etc. Over or around such exostoses bursæ will form to mitigate as much as possible the effect of friction.

(2) *Subungual exostoses*, occurring usually beneath the nail of the big toe.

(3) Exostoses due to *calcification of inflammatory exudations*, including the rare condition known as *myositis ossificans*.

FIG. 164.



Osteoma of frontal sinus (Neisser).

When a true osteoma is once thoroughly removed there is no tendency to recurrence. Thorough removal, however, calls sometimes for serious and often mutilating operations, which may become dangerous when the growth involves the curve of a rib or a large portion of the skull. At other times amputation is rendered necessary. Special forms call for special treatment suitable to the case in hand.

ODONTOMA.[1]

The **odontomata** are tumors composed of one or more of the dental tissues, arising either from tooth-changes or teeth in process of development. They may be divided, according to Sutton, as follows:

(*a*) *Epithelial Odontomata.*—These are provided with a capsule, and present usually as a series of cysts separated by thin septa, containing mucoid fluid, while the growing portions have a reddish tint not unlike sarcoma. They are most frequent about the twentieth year of life, but may occur at any age. They probably arise from persistent remains of the epithelium of the original enamel-organs.

(*b*) *Follicular Odontomata.*—These are often spoken of as "dentigerous cysts," a term used altogether too loosely. They arise in connection with permanent teeth, and especially with the molars, sometimes attaining great size and producing conspicuous deformity. The tumor consists of a wall representing the expanded tooth-follicle, and a cavity containing viscid fluid, with some part of an imperfectly developed tooth, occasionally loose, occasionally more or less displaced in location. The cyst-wall always contains calcareous material. These tumors rarely suppurate. They occur also in animals.

[1] These tumors are really of epithelial origin, since the teeth are epithelial products. They therefore really belong in Group VII., but are retained here because of their clinical resemblance to the osteomata, and lest previous classifications suffer too violent a shock.

(*c*) *Fibrous Odontomata.*—These consist of condensed connective tissue in a developing tooth, and presenting as a tumor with a firm outer wall and a loose inner texture, blending at the root of the tooth with the dental papilla and indistinguishable from it. The developing tooth thus becomes enclosed within the capsule before it protrudes from the gum. These tumors are most common in ruminants, being often multiple.

(*d*) *Cementoma.*—This refers to a tumor of fibrous character whose capsule has ossified or calcified, the developing tooth thus becoming imbedded in a mass of dental cementum. These tumors occur most frequently in horses.

(*e*) *Compound Follicular Odontomata.*—These are tumors containing a number of masses of cementum resembling small teeth, or even amounting to well-formed but ill-shaped teeth composed of all three dental elements. In such a tumor teeth may be found by the score. They are met with in the human subject as well as in animals.

(*f*) *Radicular Odontomata.*—These are tumors which arise after the crown of the tooth has been completed and while its roots are yet in process of formation. The crown, being unalterable enamel, does not enter into the composition of these growths, which then consists of dentine and cementum in varying proportions. These tumors are rare in man, but frequent in other animals, and often multiple.

(*g*) *Composite Odontomata.*—These are hard tumors, bearing little or no resemblance in shape to normal teeth, occurring in the jaws, consisting of a conglomeration of enamel, dentine, and cementum, presenting abnormal growth of all the elements of the tooth-germ. So far, this has only been found in man.

So little is said about the *odontomata* in general surgical literature that I have devoted some space to the subject here, since these tumors, as they grow, are often regarded as due to necrosed bone or to unerupted teeth, while fibrous odontomata have often been regarded as myeloid sarcomata. No tumor of the jaw, especially in young people, should lead to excision of the jaw until it has been fairly demonstrated that the tumor is not one of the above forms, and that it really is something calling for so severe an operation. When one has to deal with a true odontoma its complete removal is all that is called for, and no further sacrifice of tissue is necessitated.

Myxoma.

The **myxomata** are composed of *mucous tissue*, whose best-known normal representative is the Whartonian jelly of the umbilical cord. True myxoma should be distinguished from *myxomatous degeneration*, which occurs frequently in cartilage, fibrous tissue, and sarcoma, and which brings about a similar condition of affairs, though of essentially different origin. Myxomata appear under the following forms:

(*a*) *Polypi*, growing most often in the nose. The pure form of nasal myxoma proceeds from the mucous membrane of the nasal passages or sometimes from the accessory sinuses. The polypi hang usually as gelatinous tumors of grayish-yellow tint, being present sometimes singly, sometimes in clusters or in large numbers. Their principal effect is to produce nasal obstruction, with, perhaps, subsequent serious disorder,

due to decomposition or to extension into the pharynx or other cavities. Similar growths also occur from the mucous membrane of the tympanum, and constitute the common variety of aural polypi.

(*b*) *Cutaneous myxoma* is not common. It presents usually as a sessile tumor, although about the perineum and labia the tumors may become pedunculated. It is often difficult to distinguish between a myxoma of the skin and a sarcoma of the same which has undergone myxomatous degeneration, and which then should be strictly called sarcoma myxomatodes. The latter tend to recur after removal; hence the importance of exact diagnosis, if possible, in which the history of the case will largely aid.

(*c*) *Neuromyxoma* is a similar condition involving the nerve-trunks, and is dealt with rather under the heading "Neuroma."

Myxomata require complete removal, and in the nose especially cauterization or destruction of the surface from which they spring. When this is thoroughly done they do not recur; otherwise, they are quite likely to require subsequent operation.

Myoma.

The true **myoma** is a tumor composed of *unstriped* or *involuntary* muscle-fibre. Until very recently it has been customary to divide the myomata into the *leiomyomata* in contradistinction to the *rhabdomyomata*, the latter being supposed to be tumors of voluntary muscle-fibre. The latter, however, are now known to be *spindle-celled sarcomata* (*q. v.*), in which a certain striation of spindle-cells is often observed, and have been already spoken of in their proper place. *Myomata*, then, are met with only where *involuntary muscle-fibre* is found—namely, in the uterus and adnexa, the vagina, the œsophagus, alimentary canal, the prostate, the bladder, and the skin. They form *encapsulated* tumors composed of fusiform muscle-cells with a rod-like nucleus, the size of the cells varying greatly in different specimens. The bundles of muscle-fibres are much contorted, and it is often difficult in a single section to decide to just what class of cells they really belong.

These tumors are by all means most common in and about the uterus, and are spoken of as *intramural* when developing in the true uterine tissue, and *submucous* and *subserous* when situated closely beneath one or the other of the adjoining membranes. They differ greatly in their rate of growth, are, as a rule, quite firm in composition, and are moderately vascular, sometimes containing areas of softening and becoming even cystic. In rare instances they become enormously vascular, and have then been spoken of as *cavernous myomata*. Aside from mucoid or colloid changes, such as referred to, they occasionally undergo fatty metamorphosis or calcareous infiltration. The latter is possible even to such an extent as to lead to the condition formerly spoken of as *uterine calculi*.

Uterine myoma is quite liable to septic infection, which frequently follows exploration of the uterus or the changes incident to pregnancy or parturition. It then becomes a case for immediate and most radical surgical attack. Uterine myomata do not occur before puberty, rarely before the age of thirty-five, and are most common between the thirty-fifth and forty-fifth years of life. More definite information concerning the enormous size which they attain or the special characteristics which they display must be sought in the special treatises on Gynecology. They produce disaster not alone by their size, but by hemorrhage, by pressure on adjoining viscera (rectum, kidneys, etc.), and occasionally by torsion of a long pedicle. The operations, including myomectomy and hysterectomy, which are necessary so often for their complete removal, will be treated of at

greater length in Volume II., while for full information the reader must necessarily be referred to the special treatises.

Myomata are found in the *œsophagus* anywhere along its course, in the walls of the *stomach*, where they are frequently confounded with malignant tumors, and in the *prostate* and wall of the *bladder*. Also in connection with the *skin* they are occasionally met with. Wherever met with, so soon as they give rise to inconvenience or to dangerous symptoms they are to be dealt with surgically, since no other treatment has been proven to be of lasting benefit.

6. TUMORS OF COMPLEX MESOBLASTIC TYPE.

Angeioma.

Angeiomata are tumors composed, in whole or for the most part, of blood-vessels, and naturally group themselves under three headings, in accordance with the structure of the vascular system :

Fig. 165.

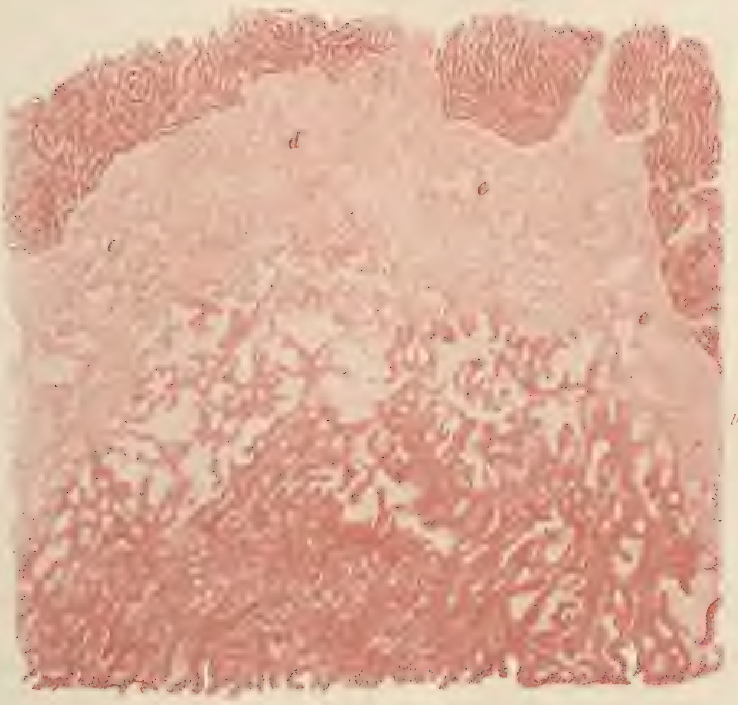
Angeioma; medullary tumor in shaft of humerus, leading to spontaneous fracture (Lanceraux).

(*a*) **Capillary angeioma** or nævus, the most common form of all, and frequently seen in the skin and subcutaneous tissue. When the condition is spread over a relatively large area it gives rise to a discoloration known to the laity as *port-wine mark*. This is spoken of by pathologists as a *telangiectasis*, referring to vessels which are present in abnormal number and of abnormal size. The condition is often congenital or begins soon after birth. According to the color of the affected area it may be determined quickly whether the vessels belong mainly to the venous or to the arterial system. These tumors may be found in all parts of the body, upon the surface, and less often are seen upon the submucous surfaces of the tongue, the inside of the mouth, the conjunctiva, and the vulva. The tendency is toward gradual increase in size; rarely spontaneous contraction and obliteration occur.

(*b*) **Cavernous Tumors.**—These are similar in structure to the corpus cavernosum, and are often spoken of as *erectile tumors*. They are most common in connection with the skin, and are simply exaggerated forms of the variety first described, the vessels becoming not merely dilated, but cavernous in arrangement. They occur occasionally in the tongue, in the voluntary muscles, and in the liver, and are noted very rarely in the mammæ, in the larynx, and subperitoneally. (*Vide* Plate XV.)

A similar condition, but much more exaggerated, is met with in the so-called cavernous tumors which involve various organs, especially the thyroid and the liver. In these instances a part or the whole of the organ may be involved, and presents great increase in size and evidences of excessive vascularity, which one cannot fail to distinguish sometimes even at a distance. In cavernous growths of the thyroid, for instance, one may meet with vessels, veins especially, the size of his thumb, while with the ear not touching the body of the patient a distinct venous murmur may be appreciated.

PLATE XV.



Cavernous Angeioma of Liver; *a*, Vascular Portion; *b*, *e*, *d*, Growing Neoplasm; *c*, Hepatic Tissue. (Klebs.)

(*c*) **Arterial or plexiform angeiomata**, which when of any particular size are ordinarily spoken of as **cirsoid aneurism** or *aneurism by anastomosis*. This form consists of arteries abnormal both in number, length, and diameter, tortuous in arrangement, occurring perhaps most often in the scalp, rarely in the perineum or genitalia, and exceedingly rarely in other parts of the body. They will be spoken of at greater length under the heading *Aneurism* in Chapter XXXII. These tumors are exceedingly liable to rupture from external injury, and call usually for ligation of the main arterial trunks, with perhaps extirpation of the tumor-mass.

Recognition of angeiomata is never difficult unless they are deeply concealed. The effect of intermitting pressure, the emptying and refilling, and the distinction between arterial and venous growths by the result of alternating pressure and relaxation, either above or below the growth, coupled with the discoloration of the skin, and, in the larger growths, the very audible murmur,—all these signs should leave one ordinarily in little or no doubt as to the character of the growth in hand.

When such growths are small they may be dealt with by electrolysis, the needles from both poles being introduced, or only from the negative, the positive being applied upon some neighboring portion of the body—perhaps with the understanding that the treatment may have to be repeated once or oftener in order to bring about final obliteration of the tumor. The effect of the electric current is to determine the coagulation of the blood in the tissues acted upon, and this, in turn, is followed by organization of thrombus, conversion of vascular into cicatricial tissue, shrinkage, and possible eventual disappearance of the mass. It is good treatment with many forms of these growths to make a radical excision under an anæsthetic, dissecting out the mass as one would any other tumor, securing bleeding vessels, and reuniting the parts by sutures, with the expectation of securing primary union. This is the quickest and in many cases the least disfiguring method. Old methods of ligation or surrounding vessels or the subcutaneous ligature are now practically discarded. Still worse, and to be most severely condemned, are the injection methods as formerly practised, especially the use of iron salts in solution. Death has promptly followed resort to this expedient, and it is now never justifiable. With the two expedients of electrolysis and excision the surgeon has at hand nearly all the measures which he will ever need to practise for the medical treatment of angeiomata. In exceptional cases other methods may be resorted to which it is not necessary to discuss here.

LYMPHANGEIOMA.

Lymphangeiomata are tumors composed of lymph-vessels and bearing an exact resemblance to the tumors just above considered. They may likewise be divided into three varieties:

(*a*) **The lymphatic nævus**, composed for the most part or entirely of lymphatics nearly normal in size, but abnormal in number, occasionally colored red by the presence of blood-vessels. When pricked, pure lymph or blood-stained lymph will flow. They are for the most part quite small, and are noticed during the earlier years of childhood. They may occur anywhere upon the surface of the body or in the mouth, most frequently in connection with the tongue, where they appear most often

Fig. 166.

Lymphangeioma of lip; macrocheilia (Neisser).

as large papillæ involving a portion or all of the dorsum. When all the lymphatic structures of the tongue are thus abnormally enlarged and involved, the condition is known as *macroglossia,* and consists of more or less enlargement of the organ, sometimes to a degree not permitting its retention in the mouth, but leading to its constant protrusion.

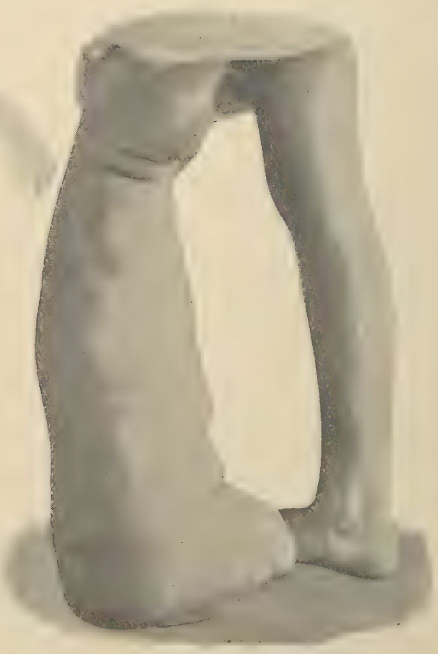
(*b*) **Cavernous lymphangeioma** corresponds to cavernous angeioma, and is a condition in which the lymph-vessels become positively cavernous and sacculated.

(*c*) **Lymph-cysts** are the still more aggravated form which lymphatic dilatation may attain, and are usually encapsulated, complicated with more or less tense tissue, and produce a condition of the parts, espe-

Fig. 167.

Congenital lymphangeioma (original).

Fig. 168.



Lymphangeioma of lower extremity (original).

cially about the scrotum and labia, to which the term *elephantiasis* is often applied.

The old question of *congenital occlusion or dilatation of lymph-channels* is one which has been made the subject of large separate monographs (especially by Bussey), and, while deserving of the greatest consideration, cannot be more than touched upon in this place. Suffice it to say that numerous tumors, essentially of lymph-vascular origin, are found upon the lips, in the neck, and elsewhere, which grow slowly, are more or less elastic and spongy upon pressure, are frequently covered by skin from which hair grows most luxuriantly, and in which pigment or papillomatous structures are dispersed, and by which diagnosis may be aided. These tumors are often spoken of as *cavernous tumors*, are of slow growth, and occasionally undergo spontaneous involution, but usually eventually call for surgical relief. They are often confused with branchiogenic and other congenital cysts of the neck.

The TREATMENT for the smaller lymphatic tumors is simple, but here electricity is less to be relied upon and excision is more urgently called for. Electrolysis will cause coagulation of blood, but not of lymph—at least not to nearly the same extent; consequently its usefulness is restricted to blood-vascular tumors. Excision, then, is almost the sole, at least the best, remedy. When this is impracticable much can be done by galvano- or ignipuncture, the cicatricial contraction following multiple punctures leading often to reduction in size of the affected part. The enlargement of the tongue spoken of above as macroglossia may be treated by ignipuncture or by electrolysis, if necessary under an anæsthetic, the effect of the electric current here being not to produce coagulation, but apparently absorption of fibrous tissue and changes which come slowly rather than by obliterative processes.

7. TUMORS OF EPITHELIAL TYPE OR OF EPIBLASTIC ORIGIN.

In this general group of tumors epithelium or epiblastic tissue is the essential and distinctive feature. According to differences in shape and disposition of epithelial cells, or according to the embryological origin of certain complex tissues (nerve), these tumors may be arranged as follows:

1. *Neuroma.*
2. *Papilloma.*
3. *Epithelioma.*
4. *Adenoma.*
5. *Carcinoma.*

But of these the first, though often considered by itself, essentially belongs here, while the fourth and fifth may be advantageously considered by themselves as Tumors of Glandular-tissue Type.

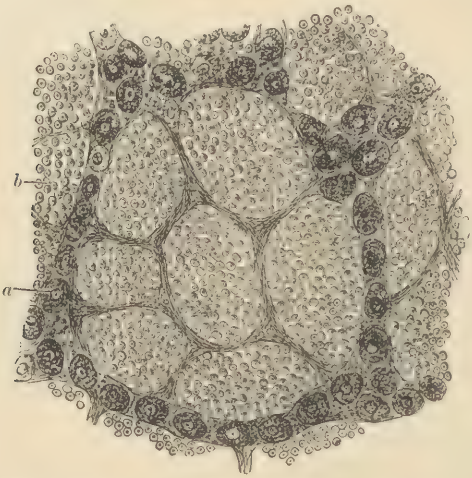
NEUROMA.

The entire nervous system is produced by infolding of the epithelial or epiblastic layer of the embryo. Hence the consideration of neuromata in this place.

True neuromata spring from the structures of nerve-trunks, which trunks may also be the site of other tumors, mainly fibromata and sarcomata, with which neuromata may easily be confounded. The most common nerve-tumor is the *neuro-fibroma,* which grows from the struc-

ture of a nerve-sheath, its long axis usually coinciding with that of the nerve-trunk. Tumors of this class vary greatly in size, are often multiple, and in other instances affect nearly all the nerves in the body.

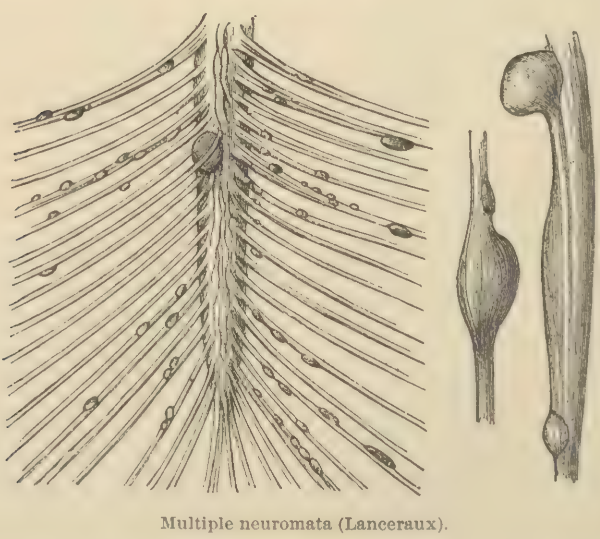
FIG. 169.



Neuroma: *a*, large nucleated cells; *b*, nerve-fibres cut transversely (Lanceraux).

They are extremely liable to *myxomatous degeneration*, which will account for many of the instances reported as *myxo-neuroma*, etc. They attack cranial and spinal nerves alike, and no nerve or nerve-root in the body

FIG. 170.



Multiple neuromata (Lanceraux).

is necessarily exempt. The sensory nerves appear more liable to attack than the purely motor. The nerve least often attacked is the optic.

They are not rare upon the roots of the spinal nerves, in which location one may attain to such size as to press upon the cord and induce paraplegia. Multiple neuromata are often associated with molluscum fibrosum (*q. v.*). There is one instance on record in which one thousand six hundred of these tumors were found after careful dissection of the neuro-skeleton, and another in which at least two thousand were found, sixty of them involving the pneumogastric trunks and their branches.

Plexiform neuroma is relatively rare. This means a type of nerve-tumor in which all the branches, for example, of a given nerve which are distributed to a particular area become enlarged and elongated, the overlying skin being stretched and thin. Such a tumor seems like a loose bag containing a number of vermiform bodies, resembling the sensation given when palpating a varicocele. On section each of the affected nerves reveals a quantity of myxomatous tissue replacing the nerve-sheath. They are in large measure congenital.

Malignant neuroma (so called) will usually be found to be a true sarcoma of nerve-structures, usually of the spindle-celled variety. *Traumatic neuroma* is most often seen in amputation-stumps, where the terminations of the divided nerves become bulbous, attaining the size of cherry-stones, the tumors being composed of a mixture of connective tissues and nerve-fibre, from which in time the true nerve-structure usually recedes or vanishes. They seem to form more often when suppuration has been profuse or healing long delayed, and most often when sufficient care has not been exercised to prevent entangling of the nerve-ends in the scar of the wound. They give rise to a great deal of pain, and often necessitate re-amputation. The bulbous enlargement seems always the result of prolonged irritation in a nerve, and has been noted around various foreign bodies.

True neuroma is innocent in tendency, though often extremely painful. It is the sarcoma of nerve-tissue which produces signs of malignancy. A true neuroma which causes unendurable pain should be removed when accessible. It is sometimes possible to separate the tumor-mass from the balance of the nerve-trunk, and thus to remove it without excision of the nerve. At other times it is impossible to avoid division and ensuing paralysis. Whenever possible divided nerve-ends should be brought together by catgut suture, by which means it may be possible to avoid permanent loss of function. Nerve-grafting is also resorted to for filling such defects. Removal of painful neuromata due to injuries to the head has more than once been the means of curing traumatic epilepsy.

PAPILLOMA.

The type of **papilloma** is the common wart, consisting of a central stem of fibrous tissue and blood-vessels covered by epithelial projections and proliferations. Papillomata are mainly *sessile* and *villous*, as well as occasionally met with in other forms.

(*a*) **Warts.**[1]—These are sessile papillomata, most common on the *skin*, often seen on mucous surfaces, and occurring sometimes singly, often in crops. They are exceedingly common about the *perineum*, where skin

[1] The *warts* are by many pathologists considered as mere evidences of hypertrophy from persistent irritation. They are here retained among the tumors lest too much violence be done to formerly-received notions.

and mucous membrane meet, and are regarded as, for the most part, due to the irritation of specific discharges. The papillomata occurring about the genitalia are ordinarily spoken of as *condylomata*. The growths in these instances are frequently so luxuriant and proliferative that they assume fungoid shape, and are often spoken of as *mulberry growths*. Warts grow slowly or rapidly according to circumstances not easily appreciated. Warty growths may attain relatively enormous size and become very vascular. Late in life they are frequently the starting-points of epithelial in-growths, and then become true epitheliomata—*i. e.* cancer. Warty growths sometimes line the buccal cavity and complicate cases of *macroglossia*. They are also met with in the *larynx*, and when situated near the glottis may cause dyspnœa or even fatal obstruction to respiration.

(*b*) **Villous Papillomata.**—These are met with most commonly in the *bladder*, occasionally in the pelvis of the *kidney*. They are strictly identical with chorionic villi. They occur for the most part singly. It

FIG. 171.

Papilloma of bladder.

often happens that long fine tufts are detached and carried away with the escaping urine: their presence when recognized should be pathognomonic. Another form of villous growth arises from the choroid plexuses of the lateral ventricles in the brain. These may grow and attain a size sufficient to produce disturbance.

(*c*) **Intracystic Villous Growths.**—These are seen, for example, in mammary cysts. These, of course, are lined with epithelium, which acts here as it does in other localities, and proliferates under unknown

circumstances more or less rapidly. In dealing with paroöphoritic cysts the presence of these growths has also been alluded to.

(*d*) **Psammomata.**—These are peculiar epithelioid tumors composed of a globular arrangement of epithelial cells in layers, enveloped by connective tissue and usually calcified. They are met with exclusively in the *pia mater* of the brain and cord. In the former case the epithelium comes from the neighboring choroid plexus. *Calcareous degeneration* is a marked characteristic, and these little tumors often feel like stone. In this respect the arrangement is identical with that in the *pineal body*. Psammomata never grow to large size: they are for the most part no larger than peas or small cherries. They are somewhat common in horses, developing from the surrounding plexus, as in man. Here they may attain the size of a walnut and still produce no recognizable disturbance. Psammomata of the spinal pia are much more serious, since here they will probably produce disastrous pressure-effects.

(*e*) **Cutaneous Horns.**—These are also epithelial outgrowths, and are met with in four varieties (Sutton):

(1) *Sebaceous horns*, quite common, arising by protrusion of contents of a sebaceous cyst through a rupture in its wall or through its duct, with consequent desiccation by exposure to the air, while fresh material is consequently added at the basis so long as sebaceous secretion continues. These growths quickly soften when soaked in weak liquor potassæ.

(2) *Warty horns*, structurally identical with the above, but growing from warts instead of from sebaceous cysts. Both these forms are found most commonly about the head. Cutaneous horns are also met with in ovarian dermoids. They are common in the lower animals and may attain large size.

FIG. 172.

Nail horns (original).

(3) *Horns growing from cicatrices*, especially of bones, are rare, but a cornified condition of the cicatrix itself, with formation of scales resembling those from horns, is not uncommon.

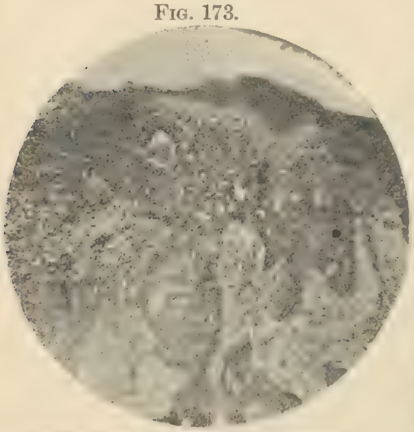
(4) *Nail-horns* are simply overgrown nails, occurring for the most part on the digits and toes of bed-ridden patients who never walk.

TREATMENT.—All these forms of epithelial outgrowth call for radical removal, after which, if effected, there is no recurrence. Radical removal, however, implies complete extirpation of the membrane or tissue from which the growth occurs, since if even a little be left there is tendency to recedive.

EPITHELIOMA.

Epithelioma is common, especially where there is transition from one kind of epithelium to another, and, of all other localities, particularly where skin and mucous membrane meet—*e. g.* the lips, the vulva, and the anus. Epithelioma differs from papilloma in that the former is no longer limited by basement-membrane, but passes beyond it into the underlying connective tissue and presents *down*—rather than *up*—growth. Characteristic of epithelioma are the so-called *cell-nests* or *pearly bodies*, where there seems to be tendency to a globular arrangement of cells with such condensation or alteration that they lose their ability to take stains, and appear as a more or less lustrous mass, showing off by contrast among the standard surrounding tissue. On this account they are often spoken of as *pearly bodies*. Recognition of these is tantamount to diagnosis of epithelioma.

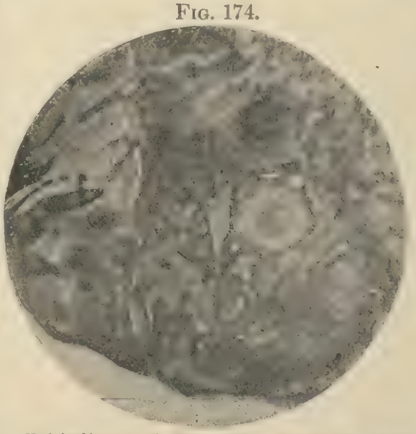
FIG. 173.



Epithelioma of face (× ¼″; Spencer).

This form of neoplasm is essentially the same, no matter what its clinical varieties. These comprise a *wart-like* growth or nodule, which quickly becomes an ulcer with elevated edges, ulceration being due to necrosis of cells farthest from the periphery; or, again, the disease may start as an *ulcerated fissure*, ulceration and infiltration keeping pace, in which case we have a sharply-defined ulcer with undermined edges. A third variety, often seen upon the lips, comprises a *projecting mass*, often with more or less horny surface. In all of these, however, the characteristic cell-nests with their onion-like arrangements of cells will be found.

FIG. 174.



Epithelioma of face, with "pearly" body (½ ×″; Spencer).

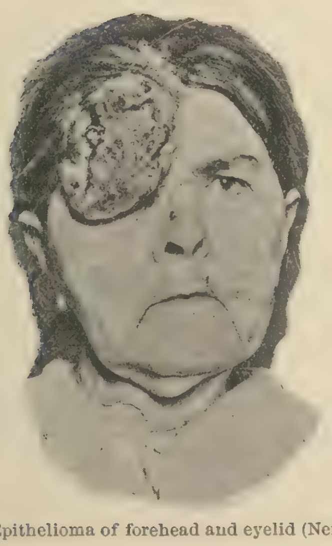
Epitheliomata, especially when exposed to the air or to surface-irritation, quickly *ulcerate* and tend to involve all the surrounding tissues, while occasionally the distinctive cells proliferate so rapidly as to give the ulcer more or less of a bursal or a *cauliflower-like* arrangement. From such a surface there is a constant discharge of foul-smelling detritus or even of sloughs. Even bone cannot resist progressive invasion and

slowly disintegrates before the advancing mass. Cartilage is most resistant, and usually preserves its integrity to the last. In other words, the tendency of epithelioma is toward constant encroachment and infiltration, and toward a fatal termination from hemorrhage by ulceration, from septic infection, exhaustion, or other accidents. The wart-like forms run the slowest course of all, but even here the malignant tendency is most evident.

Lymph-node Infection.—A striking characteristic of epitheliomata is the usually prompt *invasion of the adjoining lymph-nodes*, which attain a size astonishingly disproportionate and bearing no necessary relation to the size of the primary growth. This constitutes one of the most serious complications of the condition. This lymphatic invasion partakes of the distinctive malignant character of the disease, and from every focus of this character infiltration and destruction proceed. Infected nodes show also early a tendency to central degeneration and to spurious cyst-formation. When the overlying skin becomes involved we have extensive sloughing and the conversion into large malignant ulcers. Dissemination to a distance (*i. e. metastasis*) is rare in epithelioma—much more so than in carcinoma.

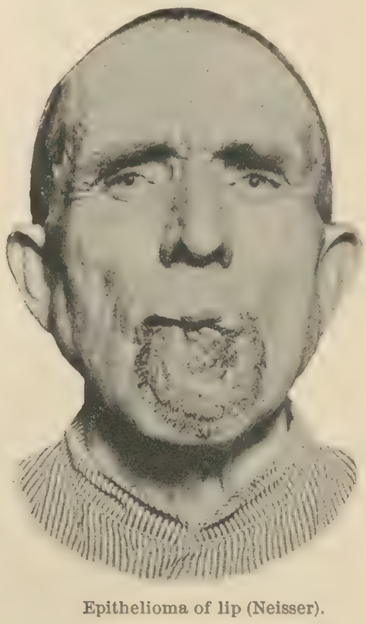
About the mouth epithelioma is not common before the thirty-fifth year of life, though I have seen it on the lip of a twenty-year-old woman. It is vastly more common in men than in women, and more frequent on the lower than the upper *lip*. In the *tongue* it seldom occurs before the fortieth year of life. It

Fig. 175.



Epithelioma of forehead and eyelid (Neisser).

Fig. 176.



Epithelioma of lip (Neisser).

seems to be more common both in the lip and tongue in men with bad teeth and in confirmed smokers, thus giving rise to the view often held that it is purely a matter of irritation. It may, however, with equal truth be laid to contact infection should one regard it as of parasitic origin. In one-fifth of the cases of epithelioma of the tongue there are preceding lesions, usually described as *leucoplakia*

or *ichthyosis* of the tongue—conditions characterized by epithelial reduplication and the formation of dense plaques or scales. These lesions are for the most part regarded as pre-cancerous conditions.

The disease often starts near the stump of a *carious tooth*, in which case infiltration and erosion begin promptly and progress rapidly. Epithelioma of the *tongue* has been known to follow down along the obliterated track of the thyrolingual duct, and in this way to bring about a perforating ulcer.

Epithelioma of the *œsophagus* is a common cause of stricture of this passageway. It leads always to ulceration, and usually eventually to perforation into the trachea or some other cavity or passage (*i. e.* a blood-vessel). In the *larynx* the disease is well known, and gives rise to intense, and finally fatal, symptoms, but has been dealt with successfully by radical operations for extirpation of the entire organ.

Occurring upon the *scrotum*, epithelioma has been in time past spoken of as *chimney-sweeper's cancer* or *soot-warts*, and has been usually ascribed to the irritation of foreign material. Ulceration and infection of the inguinal nodes proceed usually rapidly and disastrously. There is much reason also to believe that tar and paraffin may produce similar irritation, and *paraffin cancer* has been described by various writers. It occurs also usually upon the scrotum.

The skin-lesions which precede the formation of paraffin cancer resemble very closely those seen in chimney-sweeper's cancer. The skin becomes dry, thickened, parchment-like, while the openings of the sebaceous glands become obstructed by the tar or other material, producing acne-like lesions. Warty outgrowths then occur, and these become the seat of malignant ulceration.

In chimney-sweeper's cancer the scrotum is usually first affected in a chronic dermatitis, to which warty outgrowths succeed, these enlarging and growing downward as ulceration takes place.

About the external genitalia epithelioma is not uncommon, particularly in and about the *prepuce*. Such a degree of phimosis as leads to retention of smegma is certainly a predisposing cause, not only in man, but in the lower animals. Epithelioma of the *vulva* has been described under the name *esthiomène*, and requires to be recognized and dealt with promptly if one would attempt a radical cure. In the *vagina* and about the *cervix uteri* it is common, a large proportion of cases of cancer of the uterus being essentially epitheliomata of the cervix.

In and about *scars* epithelioma is quite common; also upon *granulating ulcers*. One danger to which a chronic ulcer is always exposed is that of epitheliomatous transformation, and in time past disaster has been the penalty of lack of early recognition. These growths also attack *lupus-scars*, or even any tissues actively involved in the lupoid process. This is particularly true between the fortieth and sixtieth years of life. *Vide* p. 97.

Among the viscera, the *gall-bladder* is probably more often involved in distinct epitheliomatous changes than any other. It presents as a pretty uniform thickening, and causes augmentation in size, so that a distinct tumor projects from beneath the liver. In this location dissemination is rare.

Epithelioma is to be regarded as having an essential and too often a rapidly malignant tendency, and should be attacked from the very outset with determination and without mercy. Its successful treatment demands early and wide removal of diseased parts and complete extirpation of all involved lymph-nodes—both of these to be carried out without regard to anything but complete removal. The involved tissue being excised, the question of plastic closure of defect or operative atonement for loss of tissue may call for the best of judgment and the highest degree of operative skill, in order that the best cosmetic results may be obtained. It is only the very small and incipient growths which ought to be ever attacked by such destructive agencies as cancer-pastes or the electrolytic current. While these occasionally give satisfactory results, their use is for the most part unscientific, and therefore barbarous.

Rodent Ulcers.—Under the name of *rodent ulcers*, *herpes exedens*,

lupus exedens, noli-me-tangere, etc. writers, for the most part English, have described a variety of epithelioma commonly met with upon the face to which in time past a separate classification has usually been assigned. Until recently it has been generally regarded as a local ulceration, distinct from cancer. In most of the older text-books it is referred to as *lupus exedens.* It is preceded usually by a nodular condition of the skin, quite vascular, breaking down into a regular ulcera-

Fig. 177.

Fig. 178.

Rodent ulcer (original).

tion, but little, if at all, elevated, the base of the ulcer deeply excavated, with a striking disproportion between ulceration and new growth. In this particular variety infiltration seems to be continuously in advance of the rodent process, the former being excessive, the latter but slight. This variety of epithelioma rarely, if ever, produces lymphatic involvement; the discharge is slight, the pain complained of inconsiderable. Occasionally it entirely alters its aspect, and in whole or in part presents features of the conventional epitheliomatous type.

Rodent ulcer allies itself rather with the type of tubular epithelioma springing from the outer sheath of the hair-follicle, sending out cylindrical processes which freely blend with one another.

Rodent ulcer is to be regarded as an equally malignant type of ulceration with other cancerous ulcers, and demands the same thorough and radical measures for its relief as do any other forms of epithelioma. It is perhaps the most favorable one to deal with, because of the usual freedom from involvement of deep lymphatics. No distinctive measures are necessary for its relief—only those which are thorough and merciless.

8. TUMORS OF GLANDULAR-TISSUE TYPE.

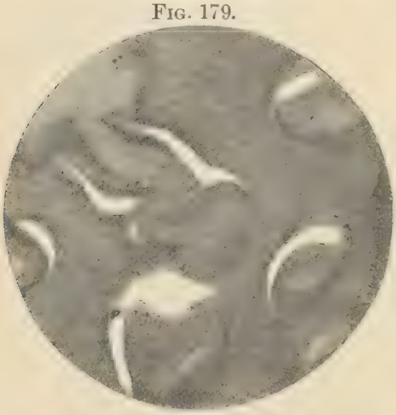
These include adenoma and carcinoma.

Adenoma.

Adenoma is a tumor whose type is the *normal secreting gland,* from which it differs in being an abnormal outgrowth or product, but par-

ticularly in that it has *no power of producing the secretion peculiar to the gland-tissue* or type from which it grows. The adenomata occur for the most part as circumscribed tumors in the *mammæ, parotid, thyroid, liver,* and in the *mucous membranes* of the bowel and the uterus. They may be single or multiple; in the intestine they are usually multiple. In certain locations (*e. g.* the mamma) they attain occasionally enormous dimensions, and in the ovary tumors of this character may be met with weighing forty or fifty pounds. The true adenoma shows no tendency to infection of neighboring lymphatics, and gives rise to no secondary deposits, and when it causes death it is usually because of size or pressure upon important organs. It displays a marked tendency to cystic alteration, while the relative proportion of epithelium and connective tissue or stroma varies within wide limits. In certain cases, where the former is small in amount, the great preponderance of the latter has caused the use of the term *adeno-sarcoma,* which is really a misleading name.

Fig. 179.



Adenoma (rectal polyp) (Spencer, ¼" obj.).

The *distinction* between *adenoma* and true *carcinoma* is in some respects but slight; and this fact will account for the conversion which many innocent gland-tumors seem to undergo from adenoma into carcinoma. So soon as the epithelial cells lose their regularity of disposition and collect in groups or make their way outside of the acini into the tissues, then the change from the benign to the malignant tumor has begun and the entire clinical aspect of the case has altered. This change may be the result of external irritation, of such tissue-changes as pregnancy and lactation, or of the undefined influence which advancing years seem to produce.

Adenoma occurs in the *breast* as *cystic adenoma* or *fibro-adenoma.* The former attains often large size, are encapsulated, the acini are much dilated, and from the walls of the epithelium-lined cavities frequently project papillomatous processes, forming what are called *intracystic* growths. Cystic adenomata grow slowly, produce atrophy of mammary tissue by pressure, occur after puberty until the menopause, and rarely give rise to pain until they become large. As they grow they distort the breast until it may become very pendulous.

Fibro-adenoma occurs also in the breast as a small tumor, encapsulated, usually superficially placed, movable in its site, often multiple; most common between the twentieth and thirtieth years of life; often painful, especially during menstruation; tender upon pressure. Both forms may occur in *young men.* A form of fibro-adenoma in which fibrous tissue is greatly in excess, which never attains great size, is common in the breasts of unmarried women. They give rise to much pain and distress, but are clinically not malignant.

Adenoma occurs frequently in sebaceous glands, as—

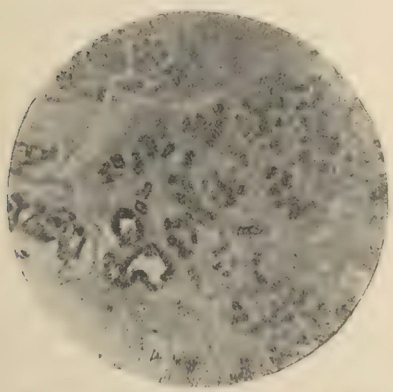
(*a*) **Sebaceous cyst,** ordinarily known as "wen." These tumors commonly begin as retention-cysts, the duct of the sebaceous gland becoming occluded. But in many cases there is no occlusion of the duct, and the secretion may be easily expressed on pressure. They occur wherever sebaceous glands abound, but especially often upon the scalp.

They are usually multiple, vary greatly in size, are easily movable over the bone, and are intimately related to the skin, while the duct-orifice is frequently recognized by a black spot, on removing which sebum can be expressed. These cyst-adenomata are encapsulated, and can be easily shelled out of their matrices, save when inflamed; in which case they are often astonishingly adherent. Their contents consist of pultaceous débris resembling old epithelial scales, fat, cholesterin, etc. The contents of these cysts are very prone to decompose, and they become as offensive as anything with which the surgeon has to deal. Putrefaction may be independent of inflammation or coincident with it. When irritated these gland-cysts become inflamed and may suppurate, suppuration being tantamount to cure by spontaneous processes. They may also ulcerate, without suppurating, and form foul-smelling ulcers, or give rise to cutaneous horns, as already mentioned.

(*b*) **Sebaceous Adenomata.**—These spring from the sebaceous glands, which are lobulated like those about the nose and ear. Adenomata from this source are extremely liable to ulceration, may undergo calcification, and are often mistaken for epithelioma because of the fungous ulcerations to which they give rise.

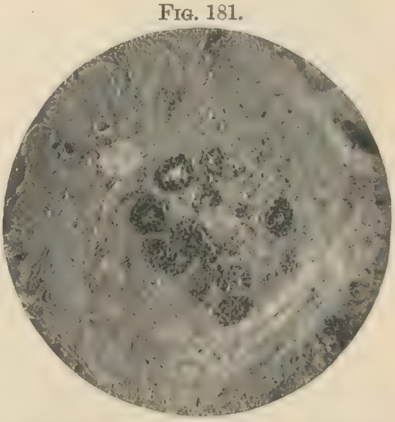
(*c*) Sutton has also described an **adeno-carcinoma** of the peculiar sebaceous glands named after Tyson. These are found particularly at the base of the prepuce, this form of tumor being exceedingly rare.

FIG. 180.



Adeno-carcinoma; × 65 (Spencer, ½″ obj.).

FIG. 181.



Adeno-carcinoma of breast; × 170 (Spencer, ½″ obj.).

Adenomata springing from the *mucous glands*, which are usually quickly transformed into cysts, are also known, as well as other gland-tumors springing from the glands of Bartholin, Cowper, etc. They are, however, so infrequent as to not deserve further mention here.

Adenoma of the *thyroid* body is described in Clinical Surgery usually as **cystic goitre or bronchocele.** It constitutes for the most part an encapsulated tumor containing structures similar to that of the normal tissue, forming tumors of various sizes, usually single, sometimes double, and occasionally occurring in the isthmus of the thyroid. These tumors contain central cavities with colloid fluid often heavily loaded with cholesterin. As they grow older and larger all traces of original

thyroid tissue disappear, and we then have to deal with a cyst with a toughened, often calcified, wall. *Thyroid adenomata* usually are easily enucleated, even when they attain large size. When small they usually cause little trouble or pain; when large they may give rise to alarming dyspnœa, and may thus jeopardize life.

The *pituitary body,* which is analogous to the thyroid in structure, is occasionally occupied by an adenomatous tumor closely corresponding to that just considered.

In the *prostate* adenoma is not rare, since its structure is composed of mixed involuntary muscle and glandular tissue. Many instances of the senile enlarged prostate are due to adenomatous alterations. The so-called third lobe of the prostate, as found enlarged in old men, is usually an adenoma of the portion posterior to the veru montanum, which has grown into the prostatic urethra or toward the bladder, because this is the direction of least resistance.

Fig. 182.

Congenital adenoma (cystic) of kidney (original).

In the *parotid* and other *salivary glands* true adenoma is occasionally observed. Almost always it is distinctly encapsulated, but may have undergone marked cystic changes.

Adenoma is common in the *liver,* either as a single or multiple lesion. Its pseudo-ducts often contain inspissated material of bile-green tint.

In the *kidney* adenoma presents for the most part as a congenital adeno-cystic lesion, which is by no means rare. Both kidneys are usually eventually involved and the outlook is most unfavorable. By this lesion the kidneys are converted into *cystic masses,* and most resemblance to original structure is lost. They may, when thus affected, attain great size.

The clinical aspects of some of these cases necessitate early operation. In one instance I removed an enormous cystic tumor of this kind from a little child of twenty-three months by abdominal section. The child was the youngest which up to that time had ever survived nephrectomy, and lived for several years, until, eventually, the other kidney acted in the same manner and caused his death. *Vide* Fig. 182.

In the *ovary* we meet with adenoma, in which, however, there will be seen but little imitation of true ovarian tissue. In the *testicle* there is known to be a form of adenoma originating in the paradidymis, in no way connected with the secreting structure of the testis, but leading often to cystic alterations.

In the *mucous membrane* of the *stomach* and *bowels* adenoma presents usually as an ovoid tumor, attaining possibly such size as to give rise to mechanical obstruction either by pressure or by traction. Adenoma of the pyloric region is a repetition in structure of the pyloric glands. In the *rectum* it presents, for the most part, as a polypoid outgrowth, most

often met with in young children. Such tumors are generally small, and when solitary they often hang by a distinct stalk.

Similar polypoid tumors present in the cervical canal of the *uterus*, where also are found sessile and racemose tumors; all of which are structural repetitions of the glands met with in the cervix uteri. Adenoma of the uterine cavity is most rare; it is also rare in the *Fallopian tube*, but occasionally presents as a dendritic outgrowth from the mucous membrane distending the tube.

Carcinoma.

Carcinoma is a tumor always *springing from pre-existing gland-tissue*, which it more or less closely resembles in type, save that the *structural mimicry is incomplete*, the epithelial cells now collecting in irregular clusters, or filling the acini and obstructing the ducts, or bursting beyond the basement-membrane and invading the surrounding tissues. They frequently so fill the ducts as to appear in columnar arrangement when seen under the microscope, and this has given rise to the use of a term so vague as to have no place in pathology—*i. e. cylindroma*. Carcinomata may arise from any of the secreting glands, but much more commonly from some than from others. They have *no capsules;* they *infiltrate* the surrounding tissues, usually *involve the lymphatics* early, are prone to *spread to the superficial tissues* and to *ulcerate*, and to *undergo various degenerative changes*. Nearly all cancerous tumors abound in lymphatics, which will explain the rapidity with which the lymph-glands become infected, as well as the tendency to dissemination which is characteristic of these growths. Dissemination leads to so-called secondary or *metastatic* growths, which may make their appearance in any organ or tissue, even in the bones, where they give rise to changes of texture that make spontaneous fracture easy. It is characteristic of carcinoma that the metastatic tumors which it may produce will reproduce almost perfectly the type of the primary tumor whence the embolic fragments which have produced them spring. The amount of dissemination varies exceedingly: it may even become so marked and so widespread as to produce a condition analogous to that met with in miliary tuberculosis, and consequently spoken of as **miliary carcinosis**. A similar condition, much more rare, is met with in dissemination of sarcoma, and is known as *miliary sarcomatosis*. A constantly-spreading cancerous infiltration of the superficial tissues, which is noted most often after mammary cancer, is described under the form of **cancer en cuirasse**, or **jacket** or **corset cancer**. Sad instances will be seen in which this infiltration of the surrounding structures has extended nearly or even completely around the thorax. It gives rise to a brawny induration which is most unyielding, and which is studded here and there by nodules that tend to ulcerate, to fungate, and to bleed easily. It is perhaps the most hopeless form of cancerous disease.

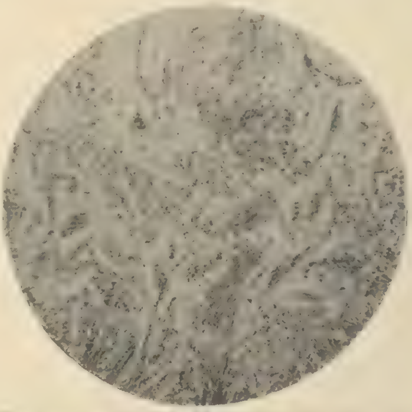
The older writers have constituted two or three clinically distinct forms of carcinoma, based mainly upon the relative hardness or softness of the tumor and the invaded tissues. The term *scirrhus* is, *e. g.*, thus applied to a tumor in which connective tissue preponderates and epithelial cells are relatively deficient. On the other hand, the term *encephaloid* has been applied to a tumor in which the connective tissue seems barely sufficient to hold the mass together, while the

epithelial cells are in vast preponderance. These are all tumors of the round epithelial-celled type, and these distinctions are of clinical interest, yet have no great pathological import, save that in a general way the greater the proportion of epithelial elements the sooner will life be terminated by destructive processes. In other words, *the more the tumor may partake of the encephaloid type the worse the prognosis* or the shorter the probable duration of life. Again, these tumors pursue

Fig. 183.

Soft (encephaloid) carcinoma (× ¼″; Spencer).

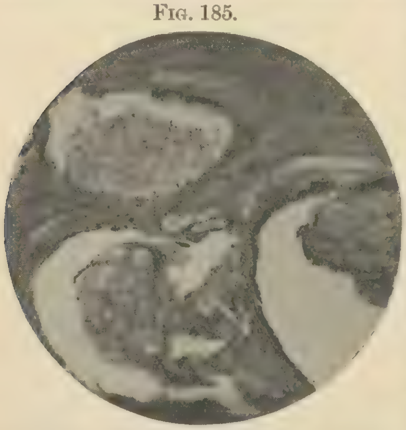
Fig. 184.



Scirrhous carcinoma of breast (× ¼″; Spencer).

a widely varying clinical course. In those, particularly of the scirrhus type, where the connective tissue largely preponderates, there is often an eventual reduction in the size of the part involved, and such reduction of vascularity and of nutritive activity that the rate of growth is thereby very perceptibly checked. The so-called atrophying cancers of the breast are the best examples of this type of cancerous disease. Here the volume of the gland is diminished rather than augmented, and the disease may last for a number of years, even so many as twenty. It is questionable whether in the presence of this type of disease it is well to operate. It would scarcely seem so, at least, in old and more or less enfeebled women, for it has usually been found that these live longer and in greater comfort if treated symptomatically.

Fig. 185.



Carcinoma of rectum undergoing colloid degeneration (× ¼″; Spencer).

The so-called *colloid forms of cancer* are simply the expression of pathological changes occurring in growths of more distinct type. Thus, colloid softening may occur in any tumor in which cancer-cells predominate, and the so-called colloid cancers of the peritoneum, the ovary, etc. are either examples of such alterations or are possibly *endotheliomata* arising in these locations. The term *villous cancer*, with other terms like it, should be expunged from all scientific literature, unless these terms be used in a purely adjective and clinical sense, for they imply nothing accurate as to the histological structure, and are too often misleading and inaccurate.

Carcinoma is most common in the following regions:

In the **breast** it appears particularly in two forms (Sutton):

(*a*) **Acinous Cancer,** and

(*b*) **Duct Cancer.**

(*a*) **Acinous carcinoma** is most often of the scirrhous type. It may arise at any portion of the breast, and if anywhere near the nipples it will early cause *retraction* of that prominence, which is always pathognomonic when noticed. When elsewhere situated it leads early to puckering and adhesion of the overlying skin. These tumors infiltrate widely, especially along the connective-tissue stroma and the fibrous tissue which intersperses the fat of the breast. They are always firm, sometimes exceedingly dense, in consistence. A particular form of scirrhus, known as *atrophying scirrhus*, consists largely of strands of fibrous tissus injected here and there with epithelial cells. It is the most slowly growing of all the forms of cancer, and by its contraction tends to reduce rather than augment the size of the mamma. *Vide* also Chapter XIV. Vol. II.

FIG. 186.

"Pig-skin" appearance of cancerous breast (original).

Acinous cancer is rare before the age of thirty, most common between forty and fifty. It occurs in women in all walks and conditions of life, married and single, and is rarely noted in the male breast. The most dangerous form of all is that which appears *during lactation.* Ordinarily its progress is comparatively slow. As it augments in volume it infiltrates all the surrounding tissues, becomes adherent to the pectoral fascia, infiltrates the muscle-fibres, and finally attaches itself to the periosteum of the ribs. The infiltrated tissues tend to shrink rather than to increase in volume. *Lymphatic infection* occurs early in this form and is a pathognomonic sign. It is most common in the axillary lymphatic nodes, but may often be detected in the neck above the clavicle. When the skin is completely involved there is a tendency toward ulceration and fungoid condition. This is always preceded by the purplish appearance of the tense skin.

Pain is a very *uncertain* and *variable* feature. It is important to emphasize this fact, since in time past many of these conditions have been lightly regarded because of freedom from pain. Pain is by no means a constant phenomenon in any form of cancer, and the sooner old notions regarding it are discarded the better. On the other hand, pain is sometimes intense, either localized or radiating and referred to distant points. Pain is particularly noticed in cases which assume the form of cancer *en cuirasse.* Secondary deposits in viscera are frequently met with, particularly in the abdominal organs and the lungs; but any organ may be the seat of secondary infection, and this is found occasionally in the bone-marrow, not alone of the sternum or ribs, but of distant bones. This is spoken of as *marrow infection.* As the result of cancerous affection of serous membranes we frequently get effusions of fluid, as in the pleura, peritoneum, and pericardium: and this fluid is often blood-stained.

In consequence of pressure upon the venous trunks in the axilla there is often a swelling of the arm upon the affected side, dropsical in character, known as *lymphatic œdema.* It is one of the most distressing features of some of these cases: the arm grows heavy, the patient loses control of it, and the skin may become so distended by effusion as to cause the limb to resemble a cast rather than a living member. This is due not alone to pressure upon the veins, but to involvement of the lymphatics, and upon careful examination positive dilatation of the lymphatic vessels may be noted. Pain is a usual accompaniment of this form of œdema.

(*b*) **Duct Carcinoma.**—This appears especially about the time of the menopause, when glandular structure has disappeared and only ducts

remain. It is common, without reference to cancer in these instances, to find cystic dilatation of numerous ducts which vary in size from a mustard-seed to a cherry. These are spoken of by Sutton and others as *involution-cysts.* They are filled with mucoid material and have a bluish

FIG. 187.

Recurring carcinoma of male breast (original).

tint. They are most common upon the under surface of the gland. Such cystic breasts are common, and when appearing in diffused form may be easily mistaken for cancer. Pain is rarely complained of. *This condition is certainly a pre-cancerous stage*, since the dilated ducts are often the starting-points of cancer, and occasionally of papillomatous or villous outgrowths from their walls.

Duct cancer implies the form which arises in these dilated ducts, most commonly in the terminal branches, appearing ordinarily as a single tumor, but sometimes as a mass of separate nodules. *Intracystic* and *intracanalicular* growths of this character will often be found. When assuming the truly cancerous phases they may be spoken of as *duct cancers;* otherwise, as *duct papillomata.* In time past these have, for the most part, been spoken of as *intracanalicular fibromata.* Duct cancers are less tense than the preceding variety, and when situated near the surface often discolor the skin quite dark. It is from these cases that we often see a more or less abundant discharge of fluid resembling *bloody milk.* These tumors grow relatively slowly, lymphatic involvement is late, and in general they present the least malignant forms of breast cancer.

Carcinoma of sebaceous glands is by all means most common in those specialized glands named after Tyson, met with about the prepuce. They give rise to the common forms of cancer in this locality.

Carcinoma in the *prostate* is not common, and is usually confined to old men. Infiltration proceeds around the base of the bladder at the same time and binds the pelvic viscera together. The pelvic lymphatics become early infected and dissemination is frequent.

In the *salivary glands* carcinoma is not common; it is most so in the parotid region, occurring at middle life, growing rapidly, infiltrating surrounding parts, and tending early to ulceration.

Carcinoma of the *liver* varies not a little in its arrangement and appearance. Sometimes it appears in the form of nodules; at other times, as a more diffuse malignant infiltration by cells relatively abundant in number, so that the clinical aspects of the case conform rather to the encephaloid or medullary type.

Carcinoma of the *kidney* was formerly ordinarily described as encephaloid, meaning thereby simply a malignant tumor of soft structure. It is probable that a large proportion of these tumors were sarcomata. Nevertheless, true carcinoma of the kidney is possible, though rare.

Concerning carcinoma of the *ovary*, we must also remain in some doubt until the subject has been more thoroughly studied. That malignant tumors appear here is unquestioned; and that many of them infect the peritoneum and disseminate widely is also true: that some of them are of distinctly epithelial type may not be doubted, and yet there can be no accurate description to-day of true cancer of this organ.

On the other hand, in the *testicle* such tumors are common—more common, in fact, than sarcomata. It is quite likely that many of them arise from the paradidymis. Even here, while recognizing their clinical frequency, we need more light.

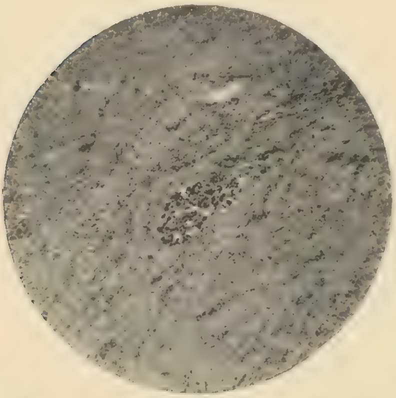
Carcinoma of the *stomach* is a common disease. It involves the tubular glands, especially in the pyloric region, and conforms to them in type. After involving, first, the mucosa, it spreads to the entire coats of the stomach and infiltrates adjacent structures, while the mesenteric lymphatics are usually early and notably involved. Were it possible to recognize this involvement early in the course of the disease diagnosis of pyloric cancer and operative interference would be much more common and hopeful. Secondary involvement is most common in the adjoining viscera, but may be seen at a distance. Miliary carcinosis has been noted after pyloric cancer. This form is most common between the fortieth and sixtieth years of life, the duration of the disease not being long.

In the *intestine*, and particularly in the *rectum*, carcinoma proceeds also from the mucous glands, and tends constantly to extend at its periphery and involve the entire lumen of the bowel. It seems to be inseparable from a tendency to contraction of the gut and consequent annular stricture. Ulceration, favored by surface-irritation and infection, occurs almost always early. Above the rectum it is most common in the neighborhood of the sigmoid flexure. Cripps has observed that when cancer of the rectum spreads downward and involves the *anus*, it loses its typical glandular character and assumes the type of epithelioma or squamous-celled cancer. In all of these cases the pelvic and mesenteric lymphatics are early infiltrated and secondary and metastatic affections are common.

Carcinoma may appear in any portion of the *uterus*, but is more com-

mon in the lower than in the upper half. It assumes the type of the cervical glands, spreads rapidly, infiltrates widely, ulcerates early, and disseminates frequently. By extension of ulceration the formation of urinary and of fecal fistulæ is common. Pyosalpinx and hydrosalpinx are also favored, because of infection from putrefying malignant tissue, while the spread of the disease is, in fact, more common when it involves the cervix than when it involves the uterine fundus.

Fig. 188.



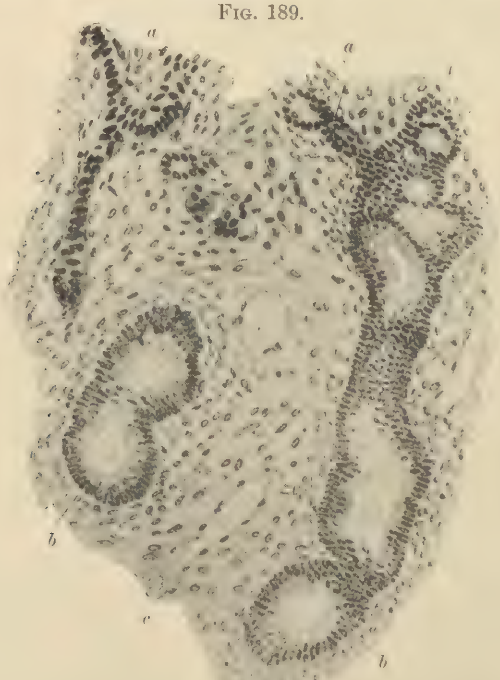
Endothelioma of liver (Spencer, $\frac{1}{4}''$ obj.).

9. ENDOTHELIOMA.

This is spoken of by Snow as the *cancer of endothelial cells.* It has gone under various synonyms in past time, and, while undoubtedly a pathological possibility, is either rare in occurrence or difficult of recognition.

Endothelioma is, as its name should imply, a tumor distinctly of endothelial tissue. The possibility of such neoplasms has been for a long time recognized, yet, in spite of arduous study of these growths, we

Fig. 189.

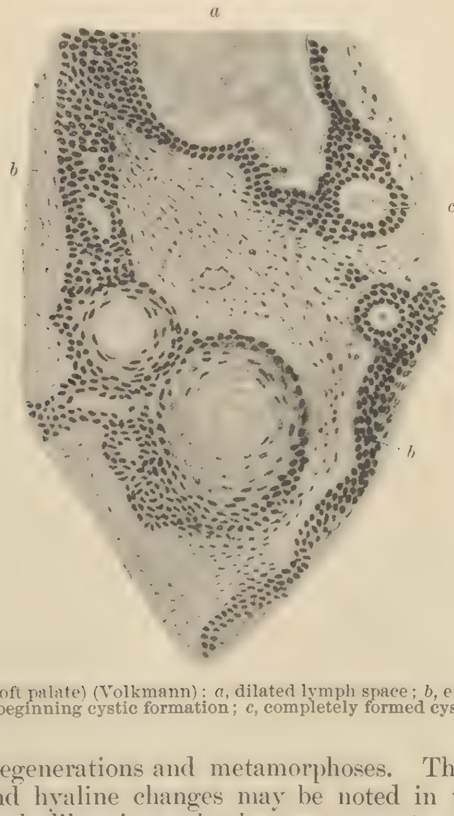


Endothelioma (of skull) (Volkmann): *a*, cell groups; *b*, cylindrical arrangement of cells; *c*, blood-vessel.

are not yet in position to speak as accurately concerning them as we could desire. They are, first of all, rare, and usually by the time they come to operation and subsequent examination have undergone changes which to some extent at least obscure their original characteristics. Considered from the developmental standpoint, they are to be considered as atypical proliferations of flat endothelial cells, springing either from connective-tissue interspaces or from the inner wall of blood- and lymph-vessels, on serous membranes, or else from the so-called perithelium of the capillaries. In one respect they may be regarded as connective-tissue tumors. Nevertheless, they are to be pathologically, if not clinically, sharply distinguished from tumors proceeding from the other connective-tissue elements. Endotheliomata are, in fact, to be abruptly separated from carcinomata and epitheliomata, although transitional forms may be observed. They are so nearly allied to certain of the sarcomata as to be often included or more often confused with them.

For the most part, these tumors proceed from the endothelial lining of lymph-spaces, less often from the other areas mentioned above. They

Fig. 190.



Endothelioma (of soft palate) (Volkmann): *a*, dilated lymph space; *b*, endothelial cells with beginning cystic formation; *c*, completely formed cyst.

undergo many degenerations and metamorphoses. Thus, cartilaginous, myxomatous, and hyaline changes may be noted in them, as well as formation of lymph-dilatations, *alveolar arrangements*, or even semblance of cylindrical or tubular construction. Some of the tumors heretofore

vaguely termed *cylindroma* in all probability belong in this class. At other times they have been confused under such names as *angeio-sarcomata* or *plexiform* or *alveolar sarcomata*, or they appear as *villous* outgrowths; and it is largely owing to this confusion that we are now certain that these tumors are of more frequent occurrence than was formerly recognized. Even psammoma is by some regarded as calcifying endothelioma. For example, most of the tumors of the salivary glands and of the soft palate belong to this class. It has been shown, *e. g.*, that 28 out of a consecutive series of 29 parotid tumors were really endotheliomata. It also appears that they may develop within the bones—for example, in the skull, in the neck of the femur, etc.—as well as in the cervical and dorsal lymphatics.[1] The endotheliomata also include the *cholesteatomata* or *pearly growths* met with in the cerebral pia mater.

Clinically, these tumors have no certain characteristics by which they can be separated from the sarcomata. It requires practically minute and microscopic examination to clearly place them where they belong. It will be enough, then, to say of them that they possess the ordinary clinical features of malignancy, including liability to recedive when not thoroughly eradicated, and that they call for exactly the same treatment as any other neoplasms presenting similarly malignant features.

GENERAL DIAGNOSTIC FEATURES OF MALIGNANT GROWTHS.

The following tables are here inserted, trusting that they may aid the young practitioner in distinguishing in a general way between benign and malignant tumors, and even in making a diagnosis between sarcoma and carcinoma. I have also inserted a table differentiating the clinical appearances of epithelioma and of lupus. In these tables comprehensiveness has not been aimed at, rather simplicity, while it is not denied that cases are met with in which diagnosis may be exceedingly difficult, and in which the common signs herein mentioned may be found either absent or misleading:

TABLE I.—*Differentiation between Benign and Malignant Growths.*

Benign and	*Malignant.*
Common at all ages.	Rare in early life.
Usually slow in growth.	Usually rapid in growth.
No evidences of infiltration or dissemination.	Infiltration in all cases, dissemination in many.
Are often encapsulated, nearly always circumscribed.	Never encapsulated, seldom circumscribed.
Rarely adherent unless inflamed.	Always adherent.
Rarely ulcerate.	Often ulcerate—nearly always when surface is involved.
Overlying tissue not retracted.	Overlying tissue nearly always retracted.
No lymphatic involvement when not inflamed.	Lymphatic involvement an almost constant feature.
No leucocytosis.	Leucocytosis often marked.
Elimination of urea unaffected.	Deficient elimination of urea (?).

[1] By all means the most able paper which has appeared upon the subject is that by Volkmann in the *Deut. Zeit. f. Chir.*, 1895, vol. xl. p. 1.

TABLE II.—*Diagnosis between*

Sarcoma and	*Carcinoma.*
Occurs at any age.	Rare before thirtieth year of life.
Disseminates by the blood-vessels (veins).	Disseminations by the lymphatics.
Arises from mesoblastic structures.	Arises from glandular (epithelial) tissues.
Distant metastases are more common.	Less so.
Contains blood-channels rather than complete blood-vessels.	Contains vessels of normal type.
Less prone to ulceration.	More so.
Involvement of adjacent lymphatics not common.	Almost invariably adjacent lymphatics are involved.
Secondary changes and degenerations are more common.	Degenerations not common; other secondary changes rare.
(Sugar present in the blood?).	(Peptone present in the blood?).

Differential diagnosis between epithelioma and ulcerating gumma will be found in Chapter X.

TABLE III.—*Diagnosis between*

Epithelioma and	*Tuberculosis* (*Lupus*).
Preceded usually by continued irritation or warty growths.	Irritation plays no figure. Preceded usually by nodules.
Diathesis plays no known part.	Diathesis evident. Coincident evidence of tubercular disease elsewhere.
Rarely multiple.	Often multiple.
Area of thickening ahead of ulceration.	Extension of ulceration not preceded by thickening.
Ulceration advancing from a central focus.	Various foci, which may coalesce.
Border usually raised and everted, regular in outline.	Border abrupt, eaten, irregular, thickened, firm, often inverted, irregular in outline.
Often assumes fungoid type.	Never fungoid.
Base may be deeply excavated.	Base nearly level with surface.
Usually painful.	Seldom painful.
Bleeds easily.	Seldom bleeds.
Never tends to cicatrize.	As marginal ulceration proceeds there is often cicatrization at centre.
Most rare in the young.	Common in the young.
Discharge is very offensive.	Discharge rarely offensive.
Lymphatic involvement nearly always.	Rarely.

GENERAL REMARKS ON THE TREATMENT OF CANCER.

Aside from the remarks already made in the earlier portion of this chapter on the general topic of Treatment of Tumors, it is best to emphasize here that the treatment of cancer is too often hopeless because instituted too late. It must be part of the teaching of modern surgery to indicate to the laity in every possible way and through every legitimate channel that it is the greatest mistake which they can possibly make to conceal the existence of tumors or to put off operative or other treatment. Little as there is to be said of cancer that can be interpreted as favorable, it must yet be acknowledged that in at least the majority of instances carcinoma originates in localities which are more or less accessible and as a local lesion, which, if radically attacked early, before the disease has spread beyond possibility of extirpation, would give vastly more favorable results. I hold, in other words, that in cases of cancer in accessible parts of the body, when operation can be made

early enough and when tissues are sacrificed in a perfectly merciless manner, there is a large possibility of cure. This involves sometimes operations which are too frightful for the average patient to contemplate. Nevertheless, the fact remains that even the pylorus may be successfully extirpated if only the operation be done at a time when disease is limited in extent and patients are not debilitated by its ravages. That carcinoma so frequently returns after operative attack, and that the outlook for these cases is so often hopeless and discouraging, are largely due to the fact that the general practitioner, under whose observation most of these cases first come, is slow to recognize the malady, timid to advise radical methods, and too frequently finds patients to whom the fatal policy of delay is more attractive than early and prompt interference. It is not, then, so much to the discredit of surgery that cancer appears in its present hopeless light as it is to the discredit of those who fail to recognize it early enough and to appreciate the urgent necessity for surgical procedures.

Enough, it would seem, has already been said to insist upon more than the expediency—the absolute necessity—of wide extirpation; and the surgeon should feel in attacking all cancerous growths that the tissue which is not plainly healthy is of suspicious character and should be removed. The mistake rarely is made of doing too much, while with unfortunate and fatal frequency its counterpart is made—*i. e.* the mistake of doing too little.

APPENDIX.

Recent Advances in Non-operative Treatment.

Inoculation Methods.—Within the past two years a great deal of interest has been excited by endeavors to apply certain well-known facts to advantage in the treatment of malignant disease. These facts have been elicited by both laboratory research and clinical experience. They are, briefly, to the effect that it has been known for many generations that in rare instances cancerous tumors have been known to cease growing, or in some cases to spontaneously disappear, **after an attack of erysipelas** involving the part. After Fehleisen had identified and studied the specific organism of erysipelas (streptococcus) experiments were made with the consent of patients suffering from this disease, deliberately inoculating them with this surgical infection. While in some instances the endeavor resulted disastrously, in others it was followed by so much of success as to justify further trial in a very limited class of cases. It was made manifest later that the effects of inoculation depended rather upon the toxic products of the erysipelas cocci than on their active presence, and thus came about the endeavor to treat this disease by the filtered products of their cultivation from which all living organisms had been carefully excluded. With these efforts in this country the name of Coley is particularly associated. The method has been even further modified to the destruction of the organisms in cultures by heat, the degree of heat necessary for their death not being sufficient to interfere with the activity of their toxic products. It is necessary, first of all, to make these cultures with organisms possessing a very high degree of virulence, those from the ordinary, so-called idiopathic, cases of erysipelas not being virulent enough to produce the desired effect.

Working with these products, by injecting them beneath the skin in the neighborhood of the tumor some remarkable results have been achieved, and in a few instances complete dissipation of the tumor has been obtained. So far as these

results are concerned, however, it must be said, that, first of all, the method is one which should be reserved mainly for the inoperable cases, *and of sarcoma rather than of carcinoma;* and, second, that there is about it no certainty of result and no absolute exemption from risk. By the use of the sterile disease-products there is no fear of conveying erysipelas, but it must be borne in mind that all these materials are pyrogenic and depressing, and that the amount required to affect the tumor-cells may be more than the general organism can safely withstand. The method is one deserving of elaborate trial, but one from which as yet no positive results can be predicted in any given case.

There is, in fact, reason to think that there are many substances whose introduction into the system may for a short time produce amelioration of symptoms or some effect upon the malignant growth. Unfortunately, these most desirable results seem, too generally, short-lived. Another recent effort in this direction is the

SERUM-THERAPY OF CANCER.—This is still newer than the inoculation-treatment, and is based on the same general principles which obtain in the treatment of certain of the infectious diseases by antitoxines formed from the serum of immunized animals. In brief, the method consists of frequent inoculation of an animal (*e. g.* a goat or a horse) with the juice of cancerous tumors or with an infusion made from them. Such injections produce temporary disturbance for a time, after which they seem to have little, if any, effect. When this time is reached a measure of blood is withdrawn from the animal, the serum separated by the usual methods, preserved with thymol in sterilized flasks, and is then used for injection into the tissues of human patients. This method is so completely in its infancy that at the date of writing one can only say that it is deserving of much further investigation. For myself, I may add that I have seen one or two remarkable results from its use.

TREATMENT BY ANILINE PREPARATIONS.—Several years ago an impure aniline preparation was placed upon the market under the fanciful name of *pyoktanin* which was alleged to have remarkable antiseptic powers. In this respect it was shown to be very deficient. It was then loudly recommended as an agent of remarkable efficiency in combating the growth of cancer-cells. In this respect it has had now a quite extended use, and there may be said of it that to a certain (small) extent the statements have been justified. When used for this purpose solutions should be made never stronger than 1 per cent., even so weak as 1 : 400. These are hypodermically injected into and around the tissues, and, while the general effect is usual by relief from pain, it will often happen that the injections themselves are irritating and temporarily painful. For this purpose it is customary to combine cocaine, and sometimes morphine, to such an extent that the injections can be made without giving rise to discomfort of more than a few moments. The effect of the subcutaneous use of pyoktanin is in many instances happy, especially in the smaller and superficial growths. It may be resorted to in other cases where the tumors are inoperable; and, while no absolute reliance can be felt that the progress of the growth will be affected or its painfulness diminished, such is, nevertheless, the effect in many instances, and the remedy is often worth a trial.

Upon the surface of malignant tumors, upon rodent ulcers, epithelial ulcers, etc. stronger solutions may be pencilled, and often with excellent effect. The color is, however, so extremely penetrating that dressings need to be carefully managed or the clothing and the adjoining parts will be stained to a quite unpleasant degree.

Aniline blue is also given internally by some, in combination with the above treatment, or alone.

CHAPTER XXVII.

SURGICAL DISEASES OF THE SKIN.

By W. A. Hardaway, M. D.

Milium.—A milium is a small, whitish body commonly found on the face; it may occur upon other parts of the body, notably the penis and scrotum of males and the labia minora of females. Milia are usually about the size of grains of sand, but may attain the dimensions of peas. If the very thin layer of skin covering a milium be incised, the mass can be turned out: it is generally soft and easily crushed, though in long-standing cases a calcareous change may occur. One or many milia may be present, and in certain regions, as the eyelids and cheeks, there may be groups of the little tumors. Milia cause no trouble beyond a slight disfigurement.

The affection is quite common in children and young adults. After pemphigus milia have frequently been observed appearing where the blebs had existed. About the edges of scars also they often occur.

It has been generally supposed that a milium was due to retention of the secretion in a sebaceous gland. Recently Robinson has expressed the opinion that some milia are due to miscarried embryonic epithelium from the hair-follicle or the rete.

A simple manner of curing milia is to incise the tumor, squeeze out the contents, and touch the little cavity with nitrate of silver. Another satisfactory method is to pierce each growth with a fine needle attached to the negative pole of five or six cells of a galvanic battery. In children frequent washings with soap and water are usually all that is required.

Acne and Comedo.—Acne is an inflammation of the *sebaceous glands* and of the *minute hair-follicles*. To acne many sub-titles have been given, most of the names used being founded on clinical differences.

Acne is essentially a disease of the young, often coming on at puberty. It usually disappears at the age of thirty or before. The sites on which the malady most commonly manifests itself are the sides of the brow, the cheeks, the shoulders, the back, and the chest. The lesions which make up the eruption of acne are *comedones*, *papules*, and *pustules*. The *comedo* is a sebaceous plug filling the orifice of a sebaceous gland; when expressed the comedo resembles a small white worm, but when *in situ* it has the appearance of a black point, from the dirt which has adhered to the end of the greasy mass. It is about the comedo that the inflammation commonly begins, leading to the formation of the acne-papule, though papules may form independently of comedones. The *papule* is at first red, conical, and firm, but in a short time suppuration sets in, and a *pustule* situated on a red base results. In

a few days this dries into a crust which falls, leaving a slight purplish stain and eventually a small pit.

All of the papules do not run this course: some undergo involution before the stage of suppuration is reached; in other cases the inflammation extends beyond the sebaceous gland and hair-follicle; a hard purple nodule forms as large as a pea or even larger, in which after some time softening occurs, with the formation of a small cutaneous abscess. To this type of acne the name *acne indurata* is given. The amount of scarring following acne depends on the number and size of the precedent lesions; sometimes it causes marked disfigurement. Acne is usually unattended by subjective symptoms. Quite frequently the condition called rosacea is an attendant of acne: the skin of the nose, chin, or cheeks assumes a more or less permanent flushed condition. After a time in the affected area dilated vessels can be seen. After this condition has persisted a long time hypertrophy of the skin and subcutaneous tissue develops. The nose is especially liable to this complication, and when markedly affected presents the appearance of a large, reddish, lobulated tumor.

Since acne is universally associated with the second decade of life, it would seem that age must be regarded as in some way an etiological factor. Many have thought that menstrual disorders play an important part in the causation of acne, and it is often noticed that in those suffering from acne new crops of lesions appear about the menstrual epoch. A thick oily skin, especially if associated with a sluggish circulation, acts as a predisposing cause. But the most important etiological factors are no doubt certain *reflex circulatory disturbances* of the skin caused by lesions of the *stomach and intestines*, such as neuroses and catarrhs. The fact that a form of acne may be caused by the ingestion of drugs, such as iodide and bromide of potassium, is well known.

As has been said, the first pathological step in acne is the plugging of a sebaceous gland with its own secretion. This either directly or indirectly determines inflammation. Attempts have been made to associate some specific organism with this inflammation, but so far unsuccessfully.

The DIAGNOSIS of acne cannot, as a rule, be difficult if the cardinal symptoms of the affection are borne in mind. It is possible that certain of the syphilides may resemble acne, but the location of the lesions, the history and concomitant symptoms of syphilis, will generally suffice to differentiate them.

Whether it be treated or not, acne will usually terminate sooner or later, but there is no doubt that by proper treatment the course of the malady can be stayed and much of the unsightly scarring prevented. In the way of internal treatment it may be said that there are no drugs which exert a specific influence on the affection, and yet in nearly every case one must use some internal medication. If anæmia exists, tonics, especially ferruginous preparations, will do good; if the patient is strumous, fresh air, sunshine, and cod-liver oil are indicated. In the vast majority of acne patients a careful investigation will prove the presence of some gastric or intestinal affection. This should be treated by regulation of the diet and habits and by such remedies as seem appropriate. When every fault in the general health of the patient is as far as possible corrected, we proceed to the local treatment of the acne. It is impossible to catalogue all the methods which have been used, and only the plan of treatment which has been most successful in the hands of the author will be mentioned.

A thorough washing of the face with hot water night and morning is of prime importance. White castile soap, or if something more stimulating seems desirable Bagoe's prepared olive soap, may be used. All comedones should be *pressed out:* this is best done after the use of hot water. A comedo-presser is necessary, and the one recommended by Piffard is the best for the purpose. It is only a modification of the watch-key with the sharp cutting edge replaced by a bevelled surface. When pustules have formed they are promptly opened with the acne-lancet. In *acne indurata* and in all cases where large, hard papules are present it hastens their disappearance to *incise* them even before pus has collected.

Of all drugs to be used locally, sulphur or some one of its preparations is best. Precipitated sulphur or equal parts of sulphur and boric acid can be used in powder form, being dusted on the affected region each night. An excellent stimulating lotion is the lotio alba, the formula for which is—Zinci oxidi, ʒij; zinci sulphatis, ʒij; potassii sulphureti, ʒij; glycerini, ʒij; Aquam ad ℥iv.—M. Sig. Apply at night. This lotion is mopped on at night after thoroughly shaking the bottle. The next morning it is washed off with hot water. After this lotion has been used for a time it will generally be found necessary to use a stronger preparation. Vleminckx's solution is a valuable remedy. It is made thus: Calcis, ℥ss; sulphuris sublimat., ℥j; aquæ, ℥x.—M. Boil to six ounces and filter. Vleminckx's solution is at first diluted with five parts of water. After this strength has been used for several nights less water is added, till finally the pure liquid is used. It is mopped on the affected regions and allowed to remain over night, when it is to be washed off with soap and hot water.

In addition to the measures indicated it is well to order the following lotion: Acidi borici, ʒiij; alcoholis, ℥v.—M. Sig. Shake and apply. This should be mopped on the face several times a day. By the evaporation of the alcohol a thin layer of the boric acid is deposited over the surface, thus keeping up a constant antiseptic effect.

Sebaceous Cyst.—Sebaceous cyst, also known as *steatoma* and *atheroma*, is a cyst which is filled with sebaceous matter. (*Vide* also Chapter XXVI., *Adenomata.*) The cysts may occur singly or there may be a number present. They are seen upon any part of the body, but occur with great frequency on the face or scalp. As usually observed, a steatoma presents as a tumor from a cherry to an egg in size, partly buried in the skin. In rare cases the tumor is pedunculated. The skin over the growth is usually normal in appearance, but it may be very thin and atrophic, or, on the other hand, thickened and somewhat reddened with dilated capillaries. The consistency may be hard or soft and doughy: this will depend in a great measure on the thickness of the cyst-wall.

In some steatomata a small depression can be found through which on pressure the thick, butter-like contents can be forced. These cysts are likely from time to time to empty a portion of their contents through the opening. In other cases the tension in the cyst becomes so great that it ruptures and afterward fills again. After sebaceous cysts of the scalp have existed for a long time the hair over them falls out.

It sometimes happens that sebaceous cysts become inflamed and suppurate,

and occasionally this results in a cure by destruction of the cyst-wall. Sometimes an ulcer with infiltrated base is left, resembling an epithelioma.

Sebaceous cysts cause no pain, and are usually annoying for cosmetic reasons only. An epithelioma may result from a sebaceous cyst. Occasionally a steatoma has caused absorption of a portion of the skull and perforation.

There is some difference of opinion among authors as to the true pathology of steatomata. Virchow classes them as retention-cysts; Winiwarter regarded them as adenomata which had undergone cystic degeneration; while Török thinks they should be considered as dermoid cysts. The cyst-wall consists of a more or less thick capsule of connective tissue lined with epithelium. The contents vary from a white, cheese-like substance to a milky-looking fluid.

It is usually easy to diagnosticate a sebaceous cyst, especially when there is an orifice through which some of the contents may be pressed. The history of the tumor will serve to distinguish it from a cold abscess, and the same factor will differentiate an *inflamed steatoma* from an *acute abscess*. Sebaceous cysts may at times be practically indistinguishable from other growths, such as lipomata or fibromata. The likeness which the fungating base of an ulcerated sebaceous cyst may present to an epithelioma has already been mentioned. A microscopical examination would generally decide the nature of the growth.

In the TREATMENT of sebaceous cyst the one thing to be aimed at is complete *destruction of the cyst-wall*, for if even a small part of this remains recurrence is very likely to take place. The most generally applicable way of accomplishing this is to dissect out the entire cyst with the knife. The skin should first be anæsthetized by cocaine injections or by the ethyl-chloride spray. In dissecting out the sac the success of the operation is ensured by taking pains not to rupture the cyst before it is completely removed. The operation must of course be done antiseptically.

The use of caustics has been advocated by many. The author much prefers the method already mentioned. In using caustics a sharp stick of nitrate of silver can be bored into the cyst, and after the eschar thus formed is separated the sac can be pulled away with forceps. A method which is said to be of special advantage when the cyst has become adherent to the skin and is difficult to dissect is to make a free incision into the cyst, and, after cleaning out the contents, to paint the walls thoroughly with tincture of iodine: in the violent suppuration which follows the wall is destroyed.

A great many other caustics have been advised, but what has been said serves to illustrate their use.

Furuncle.—A furuncle is an *acute inflammation of a hair-follicle* or *gland* of the skin which usually terminates by necrosis of the central part of the affected region with suppuration.

A single boil only may be present upon the body, but very commonly several boils in rapid succession or simultaneously affect a region. In some cases one crop after another without limit attacks a person, and this condition is designated as *furunculosis*. A boil commences as a small, red, painful, very tender papule, protruding from which a lanugo hair may generally be detected. Often at the apex of the nodule a small vesicle of cloudy serum may be seen. The papule rapidly enlarges into a conical swelling from a pea to a pigeon's egg in size. The surrounding area becomes red and infiltrated, while the skin over the boil assumes a dusky hue. At the end of three or four days the skin at the apex of the boil softens, gives way, and a small amount of pus exudes. At the opening a piece of white pultaceous necrotic tissue is now visible, which

is thrown off in a day or two, leaving a granulating cavity. With the opening of the boil the intense throbbing pain is relieved, and with the separation of the core it ceases. After healing a small bluish-red scar remains, which gradually fades to a dead white, or a slight amount of pigmentation may remain for years. A boil may not run through all these stages, but may stop short of suppuration and disappear without opening.

With large boils or where many are present a certain amount of febrile disturbance is noted; the patient loses appetite, and sleep is interfered with on account of the pain. The lymphatic ganglia in the neighborhood are often enlarged and tender, and may suppurate.

A form of boil originating in the *sweat-coil*, and first described by Verneuil, differs from the ordinary furuncle. It affects especially the *axillæ* and the *genital region*. The process commences in the subcutaneous tissue as a small firm nodule. This enlarges till a raised, red, pea-sized mass is formed, which is soft and little painful. If left alone, these little abscesses burst, giving issue to a drop or two of pus, and a crust forms, under which healing occurs.

Etiology and Pathology.—Since boils depend on the infection of the follicles by the germs of suppuration, we can readily understand that their formation is favored by circumstances which would decrease the physiological resistance of the parts, as well as by those circumstances which increase the exposure of the patient to the germs. Thus a local injury is often followed by a boil. Certain depressed states of the general constitution act in a similar manner; for instance, we know how common boils are with diabetes. Eczema and other itching diseases often predispose to furuncles, as the follicles become inoculated from the nails during scratching. Those whose occupation brings them into intimate association with opportunities for infection, as butchers, tanners, cooks, surgeons, etc., are especially liable to boils. Infrequent bathing and dirty habits may act in a similar way. Lastly, prolonged contact with a person having boils, such as sleeping in the same bed, may inoculate them upon the sound person.

The organism usually found in furuncles is the staphylococcus pyogenes aureus. The central necrotic mass constituting the core of the boil is due to the rapid action of the poison liberated by the invading micro-organisms.

Diagnosis.—The only affection with which furuncle is likely to be confounded is Carbuncle, which see for differential diagnosis.

Prognosis.—As far as life is concerned, the prognosis is good, but it is wise to be cautious in promising speedy relief to a patient who is afflicted with a succession of boils, as the surgeon often finds that this affection taxes his therapeutic resources to the utmost.

Treatment.—Though many internal remedies have been recommended in the treatment of boils, it may be said that beyond putting the general health in the best condition possible, and correcting any constitutional vice which may be present, there is nothing which we can accomplish by dosing the patient with drugs. In the earliest stage there is a chance of aborting a boil if only a means of destroying the germ in the hair-follicle can be used. For this purpose two methods commend themselves: The first was introduced by Tuholske, and consists of passing a needle attached to the negative pole of a galvanic battery down into the follicle and destroying it and its contents by *electrolysis*.

The other means has been advocated by Lowenberg,[1] and consists in destroying the affected follicle by thrusting into it the fine point of the *actual cautery* at a white heat.

If the boil has advanced beyond the stage when it can be aborted, it may still be beneficially influenced by certain topical applications, all of which belong to that class termed "revulsants." Painting repeatedly with iodine or touching with the lunar-caustic stick will often yield good results. The constant application of the mercurial-carbolic-acid plaster mull of Unna has many advocates, and in the hands of the writer has given good results. A soap plaster containing 5–10 per cent. of salicylic acid has recently been highly spoken of by Neuberger,[2] and a similar preparation was previously recommended by Klatz.

In the treatment of boils *none of the ordinary poultices should ever be used*, since they favor the development of other boils in the neighborhood of the first. If a poultice is deemed necessary, cotton wool wrung out of a 2½ per cent. carbolic-acid solution and covered by rubber tissue and a bandage is the best application. This gives much relief, and often seems to limit the suppuration. In those cases where crops of boils succeed each other Van Hoorn[3] advises this plan of treatment: The entire skin is washed with a warm bath and soft soap. The boils and the surrounding skin are washed with 1 : 1000 bichloride solution. The boils are covered with mercurial-carbolic-acid plaster mull and the patient puts on clean linen. Twice a day fresh plasters are applied, and if the boils have opened, the pus is gently squeezed out and the region disinfected with the mercuric solution.

As soon as *fluctuation* can be made out, or as soon as pus is thought to have collected in a boil, a free opening should be made with antiseptic precautions and antiseptic dressings applied. After the separation of the core, if an ulcer is left which is indolent, iodoform dusted in often serves to hasten cicatrization.

In the condition known as *furunculosis* it may occasionally happen that the patient becomes so reduced as to demand a change of climate, a course of tonics, and such other measures as are applicable after any debilitating disease.

Carbuncle.—A carbuncle is a severe *localized inflammation of the skin and subcutaneous tissue which results in necrosis*, usually at several distinct points. It is sometimes difficult in the inception of a carbuncle to distinguish it from a boil, but usually the greater gravity of the malady is announced from the beginning. Not infrequently the disease is ushered in by a *chill*, and there is nearly always considerable fever and constitutional disturbance. The site of the carbuncle is red, swollen, œdematous, and quickly gets of a peculiar *brawny hardness*. There is pain of a burning or throbbing character. The redness grows more dusky, the swelling extends, and several pustules appear upon the surface. In eight days to two weeks the process has attained its maximum, and the carbuncle is two to three inches in diameter. *Softening* now commences, but instead of pointing at one place, as occurs with an abscess, the skin gives way at *several points*, emitting small quantities of *sanious pus* and exposing a white mass of *necrotic tissue*. These

[1] *Journ. Cut. and Genito-urinary Dis.*, Oct., 1894.
[2] *Derm. Zeitschrift*, 1894, i. 387. [3] *Monatshefte f. Prakt. Derm.*, Bd. xix. No. 1.

masses gradually come away through the openings, and leave deep, ragged ulcers. As soon as the openings have formed pain grows less and the constitutional symptoms grow better.

Certain variations from this course are to be noted. The process may be much protracted by repeating itself for some time at the periphery, and the carbuncle may thus attain considerable proportions, the author having at one time treated one in an old man which occupied almost the entire region outlined by the trapezius muscle. In such cases the patient often stands in great danger of death from septicæmia. Sometimes, instead of the skin giving way at several points, it becomes gangrenous *en masse* and is cast off, leaving a deep, spongy-looking excavation, or it may undergo dry gangrene, becoming mummified. Accidents of a serious nature which may arise during the course of a carbuncle are septic phlebitis of the sinuses of the brain and septic embolism of other organs.

The most common site for carbuncles is the back of the neck, but they may occur upon the face and other parts of the body, attacking most often the extensor surfaces. It is said that patients never recover after carbuncle upon the upper lip, but the author's experience is quite to the contrary of this statement.

Etiology and Pathology.—What has been said of the etiology of furuncle applies almost equally well to carbuncle. It is usually regarded as a collection of boils. It is most common in adult life and forms a frequent complication of diabetes. The same micro-organism is found in carbuncle as has been mentioned in furuncle, and why in the one case a boil should result from its inoculation and in another a carbuncle has not been explained, except on the supposition that for some anatomical reason it happens in carbuncle that the direction of least resistance is not toward the surface.

Diagnosis.—Carbuncle differs from furuncle in its greater size, brawniness, and multiform openings. Phlegmon of the face is not so circumscribed, not so hard, not so dark red, and opens at but one point. Anthrax begins as a sharply-defined red area upon which a vesicle rapidly forms in which anthrax bacilli can be found.

Prognosis.—A carbuncle is always a dangerous affection, and especially so in the aged or those debilitated from any cause. A carbuncle on the head or face is more dangerous than on other parts of the body.

Treatment.—In all cases of carbuncle attention should be directed to keeping up the strength of the patient. To this end morphia must usually be given to secure rest, the hygienic surroundings must be made the best possible, a nutritious and easily digestible diet arranged, and alcoholic stimulants and tonics must frequently be administered. In very mild cases those local means which have been recommended in furuncle may be used, but in the majority of cases more radical measures will be called for. The method that is perhaps most generally useful is a *crucial incision* through the entire thickness and width of the infiltration, followed by the removal with the sharp spoon and scissors of all necrotic masses as far as possible. A moist, antiseptic dressing should then be applied and changed daily. A method which is much used on the Continent consists of the parenchymatous *injection of a 5 per cent. carbolic-acid solution.* A number of injections are made, and the operation is repeated if necessary, the aim being to saturate the carbuncle as thoroughly as possible short of producing carbolic-acid intoxication in the patient.

The most radical of all methods thus far proposed is that of Riedel, by which the *entire affected tissue is removed* by the knife just as though it were a malignant tumor. The method is highly spoken of, but its use will probably be confined to those cases in which urgent symptoms are presented, as, for example, profound sepsis.

Callosities.—Callosities of the skin of various parts of the body are of frequent occurrence. They are most common upon the palms of those who handle tools or the soles of those who are much upon their feet. Callosities are thickenings of the corneous layer of the skin, and represent an effort on the part of nature to protect tender parts from injurious pressure, though occasionally callosities are congenital.

As a rule, callosities do not require treatment, as they afford protection; furthermore, if removed and the occupation which excited them be still pursued, they will return. When it is deemed necessary to interfere, the part upon which the callosity occurs should be soaked in hot water containing borax; the upper layer of the callosity can then be scraped off. Salicylic acid, either in the form of Unna's plaster mulls or in a paste, such as the following, should be kept constantly applied: Talci, ʒvj; zinc oxidi, ʒv; acidi salicylici, ʒss–ʒj; vaselini, ℥j.—M. Sig. Apply.

Clavus (*Corn*).—A corn may be either *hard or soft*. A *hard corn* is really a callosity with the addition of a peg of horny scales which projects from its under surface and causes pain by pressure upon the sensitive tissue beneath. A *soft corn* differs only in that it occurs in situations where it is kept sodden by moisture. Corns nearly always occur on the feet, and are the result of ill-fitting shoes. Their usual situations are the joints of the toes, especially the outer side of the little toe. It sometimes happens that a corn becomes inflamed, and this may lead to the formation of an abscess or ulcer, or even to caries of the bone.

In the TREATMENT of corns the first thing is to remove injurious pressure and to see that a properly-fitting shoe is worn. *Hard corns* may be treated just as if they were ordinary callosities. It is well, in addition, to place a felt corn-plaster over the corn in such a way as to prevent pressure. In the case of soft corns the feet should be washed twice a day, using plenty of soap. As much of the thickened epithelium as possible should be removed with a knife, and then the following pigment painted on three times a day: Acidi salicylici, gr. xv; ext. cannabis Indic., gr. viij; alcoholis, ♏xv; ætheris, ♏xl; collodii flex., ♏lxxv.—M. At the end of a week the corn can be pulled away with the layers of collodion.

Cornu Cutaneum.—Horns growing from the skin are comparatively rare, yet on account of the striking appearance which they present they have attracted much scientific as well as popular attention. Generally, only one cutaneous horn is present, but sometimes horns are multiple. In size they vary from a barely noticeable projection to a protuberance several inches long. They resemble the horns of the lower animals, but are rougher, often twisted and bent or striated. They grow slowly, and may fall spontaneously and be reproduced. They cause no pain unless injured, when the base may become inflamed and suppurate. They occur chiefly upon the scalp and forehead, but may also affect the extremities, the sulcus behind the glans penis, and the trunk.

It is stated that not uncommonly cutaneous horns degenerate into epitheliomata. Quite frequently horns start from sebaceous cysts or warts or scars. (*Vide* Chapter XXVI., Group VII.) They are most frequent after forty years of age. Horns are essentially warts in which the horny cells are much exaggerated. They are always seated upon large papillæ.

In the TREATMENT of horns the first thing is to soften the horn by applying water dressings, having added borax to the water. Then the horn is torn off or cut off at the level of the skin. The base should be curetted, and then cauterized with nitrate of silver or chloride of zinc.

Verruca.—*Warts* have been variously named according to certain characteristics which they present, and for clinical purposes it is well to retain these titles.

Verruca Vulgaris.—This is the form of wart so commonly seen upon the hands of young persons. Generally, a considerable number are found upon the body. They are sessile growths, from a pinhead to a pea in size, either with a smooth surface or beset with numerous little elevated points. Usually of a yellowish color, they may from accumulation of dirt become blackish. These warts are most frequently found on the hands, but may be seen upon any part of the body.

The Seborrhœic Wart.—This form occurs quite frequently upon the faces, backs, and arms of elderly persons. They are usually pigmented of a brown or black color, and present upon their surface a certain amount of scaling. They often itch intolerably.

Verruca Digitata.—In this form the development of the individual papillæ is great, giving rise to several long, finger-like processes seated upon a common base. These warts are found especially on the scalp, and one or several may be present. When only a single papilla is specially enlarged, the name *verruca filiformis* is given to the wart: it is found frequently on the eyelids.

Verruca Acuminata.—This form of wart, to which the term venereal is also applied, occurs with much frequency about the genital organs and the perineal region of both sexes, but may be found in almost any other situation. The growths are pointed or sessile, and are often compared to various vegetable growths, as a cauliflower, a mulberry, etc. On parts of the body where they remain dry they are the color of the surrounding skin, but in the region which they most often affect they are constantly moist and become covered with a whitish, mucus-like coating and exhale a very disagreeable odor. If the coating is wiped off, bright-red, easily-bleeding tufts are exposed. These warts sometimes develop with great luxuriance, forming masses as large as the fist.

Until recently we have been entirely ignorant as to the etiology of warts, but now the opinion that they are due to a parasite is becoming more and more general. A number of instances of contagion can be cited in support of this belief. *Verruca acuminata* occurs especially where regions are kept moist by a chronic discharge; for instance, gonorrhœa, or during pregnancy, when an unusual activity of mucous secretion occurs in the female genitals. Anatomically, all warts consist of a central vascular connective-tissue covered by more or less epithelium.

Until recently the TREATMENT of warts has been purely local. Colrat made the observation that magnesium sulphate, given for some time in doses of ten to thirty grains three times a day for adults, was capable

of curing warts. Other observers have borne witness to this, and the method is certainly worth a trial. A great many methods for the local treatment of warts have been advised. Some one of the caustic agents may be used. One of the best methods is by applying salicylic acid in the form of a plaster or in collodion, as recommended for corns, or, where the warts are very close together, by applying a saturated solution of salicylic acid in alcohol several times a day. It is often necessary to resort to stronger remedies, among which may be mentioned chromic acid, acid nitrate of mercury, and trichloracetic acid. The filiform warts may be snipped off with scissors and the base cauterized. An excellent manner of removing warts is by means of the electrolytic needle. The needle attached to the negative pole of five to ten cells of a galvanic battery is passed several times through the wart just above the level of the skin. It is better not to attempt to complete the operation at one sitting, but to operate at intervals of a week or two, as in this way scarring is best avoided. In the treatment of acuminate warts the chief point is to keep the parts dry and clean. Frequent washings are necessary, followed by dusting with a powder, such as this: Acidi borici, ʒj; hydrarg. chlor. mit., gr. x; acidi salicylici, gr. x; zinci stearatis, ʒij.—M. Where two surfaces which lie in apposition, as the glans penis and preputial sac, are affected, a piece of absorbent cotton should be interposed. When the growths are very luxuriant, they may first be trimmed away with the scissors and then the bases touched with pure carbolic acid or some other caustic. When these warts arise during pregnancy it is not necessary to treat them, as they nearly always disappear after delivery.

Nævus Pigmentosus.—A pigmented nævus is a *congenital deposit of pigment* in the skin which may or may not be accompanied by other changes in the integument. *Moles* have been variously named according to their clinical appearance. *Nævus spilus* is the name given when nothing more than an abnormal pigmentation is observed. Such moles vary in size from a pinhead to a dime or even larger, and in color from fawn to black. Though most common on the back, they may be found on any part of the skin. If the surface of the mole is thrown into folds and ridges, it is called *nævus verrucosus*. Very commonly a number of hairs, fine or coarse, spring from the nævus, and the name *nævus pilosus* is given. If soft, papillary growths cover the surface, the mole is termed *nævus papillomatosus*. Some large moles contain a good deal of fat, and may resemble dermatolytic growths, thus receiving the name *nævus lipomatodes*. Lesions occur in all respects similar to raised pigmented nævi, except lacking the color, and are spoken of as white moles.

Moles vary much in size and number in different individuals. They are especially often found on the face, neck, and back. Sometimes a pigmented nævus covers a large region of the body; again, a number of pigmented nævi may be found in the course of some nerve. Sometimes a *sarcoma* or a *carcinoma* springs from a pigmented nævus, and this renders the affection of more surgical importance than it would otherwise be.

If the surgeon is asked to remove a mole for cosmetic purposes, it is well for him to be quite sure before undertaking the operation that the resulting scar will be less disfiguring than the mole. If a mole with

hairs is to be dealt with, the hairs should first be removed, and then, after sufficient time has elapsed for the full effect of the operation to become evident, what remains of the mole can be dealt with. The electrolytic needle gives the best results. In its use it is best to proceed carefully, doing a little at a time, as in this way scarring will best be avoided. Generally it will not be possible to remove all the pigment, but usually its amount can be much lessened and the mole can be brought to the level of the surrounding skin. If removed by the knife, as a rule too much scarring results. The caustics are unsafe. If a mole is where it is constantly irritated, as by the clothing, especially in advanced life, or if a mole shows a tendency to grow rapidly or to ulcerate, it is wise to remove it without delay.

Nævus Vascularis and Telangiectasis.—By a *vascular nævus* we mean a growth which is characterized by an increase in number and size of the blood-vessels of a part of the skin. If the blood-vessels have become dilated after the individual has reached adult life, they are usually spoken of as *telangiectases*. (*Vide* Chapter XXVI., Group VI.)

A vascular nævus may be present at birth or it may first manifest itself after weeks or months. Only one may exist or numbers may occur upon the same person. The nævus may occupy a space no larger than a pinhead, or, on the other hand, large areas may be involved. In color nævi vary from a light red to a dark purple: if pressure is made a part of the color disappears, but rapidly returns as soon as the pressure is removed. Some nævi are quite flat and level with the skin, but others are raised and the surface rugose, warty, or presenting little tumors darker than the rest of the growth. In the elevated growths it can frequently be seen that the tumor grows more turgid on straining or crying, and in a few of these growths pulsations synchronous with a heart's impulse can be felt; in these tumors a bruit may be heard.

Nævi have received special names founded upon certain clinical peculiarities. The *birth-mark* may consist of a central red dot with radiating red lines springing from it; this has been called *nævus araneus*. When the nævus occurs as a large red or bluish discoloration, it is called a *port-wine mark*. A nævus may be so much raised above the surface as to form a veritable tumor, which is usually of a purplish color, and, though easily emptied of blood by pressure, rapidly fills again. On account of their reticular structure the term *angioma cavernosum* has been applied to such growths. Sometimes the angioma lies entirely in the subcutaneous tissue, the skin over it not showing any change. Vascular nævi occur also upon the mucous membranes, and do not differ in any essential particular from those which affect the skin. Though nævi occur upon any part of the body, they are most frequently seen upon the head, face, and extremities. They are of importance chiefly on account of the disfigurement which they cause.

The COURSE of nævi is always uncertain. In some cases they disappear as life advances, but, on the contrary, those which have seemed of little importance may suddenly and unaccountably grow. Various complications may arise with a nævus; the skin covering the growth may ulcerate and alarming hemorrhage follow, or a traumatism may precipitate the same evil. It occasionally happens that a nævus and the surrounding tissue become gangrenous. There are, as a rule, no subjective symptoms with nævus vascularis.

Telangiectases develop as *secondary* phenomena, although it may be

at times difficult to ascertain the cause. The usual sites for telangiectases are the face, the neck, and the upper part of the trunk. One of the most common clinical forms exactly resembles the nævus araneus. In other cases small red or bluish vessels are seen coursing over the skin. These are frequently seen in elderly persons upon the cheeks and in those suffering from rosacea. In other instances the telangiectasis occurs as a smooth red or purplish elevation, the surface of which may in the course of time become tuberculated, so as to resemble a raspberry. In some rare instances almost the entire surface has been occupied by telangiectases. Telangiectases are not infrequently seen upon *mucous membranes*, as about the nares, in the conjunctiva, and in the pharynx. Sometimes a telangiectasis spontaneously disappears, but more commonly it increases in size and others develop in its neighborhood.

ETIOLOGY.—Since maternal impressions can no longer be accepted as a cause for vascular nævi, we are in the dark as to their etiology.

Telangiectasis can result from any cause which produces long-continued congestion of the skin, such as interstitial changes in the kidneys or liver, emphysema, and other chronic lung troubles. Local obstructions to the cutaneous circulation also cause them; consequently we find them at the periphery of scars, over new growths, and with inflammatory troubles, such as acne rosacea. They form an essential feature of Kaposi's disease.

PATHOLOGY.—The pathological anatomy of even the simplest vascular nævus is frequently complicated, for not only is there an increase in the number of vessels of the part affected, but their walls often present marked changes. The pulsating nævi are made up of a mass of arteries and veins confusedly twined together. In the cavernous nævus there are intercommunicating chambers formed by trabeculæ of connective tissue lined with endothelium.

DIAGNOSIS.—There is no difficulty in making the diagnosis of nævus vascularis or of telangiectasis if the peculiarities mentioned above are kept in mind.

PROGNOSIS.—The prognosis in both nævus vascularis and telangiectasis must be guarded. It often happens that a flat nævus, insignificant at first, extends or develops into a pulsating angioma. Telangiectases are apt to keep on forming unless the predisposing cause can be removed.

TREATMENT.—In some of the more formidable vascular nævi serious surgical operations, such as ligature of the large vessels or even amputation of the affected part, may be necessary, but here only those cases suitable for treatment by the ordinary means of the dermatologist will be considered. The methods of treatment which have been found most generally useful are—*destruction by chemical agents*, *extirpation by the knife*, and *coagulation and inflammatory obliteration by electricity*.

1. *Destruction by Chemical Agents.*—In the case of superficial nævi the application of some caustic agent may suffice for a cure. Ethylate of sodium has been recommended, because it leaves only a superficial scar. Its use is tedious, as it must be repeated several times, and it is a preparation difficult to obtain. Nitric acid, acid nitrate of mercury, and chloride of zinc are other caustics which, properly used, give good results. In using them the application should be carefully made, lest more destruction of tissue and scarring result than is necessary for the cure of the nævus. The sloughs which form should be allowed to

separate of themselves. The injection of irritating chemicals into elevated nævi has often been practised, but this is not a safe method and should not be used where other means will answer.

2. *Extirpation by the Knife.*—If the nævus is small and so situated that tissue can be spared, probably no other method is more satisfactory than excision, as there is thus left only a linear scar. In removing a nævus by the knife the incision should be made well outside the affected area, as otherwise the hemorrhage may be great and the growth may recur.

3. *Coagulation and Inflammatory Obliteration by Electricity.*—For the cure of vascular nævi electricity may be used in two ways—as electrolysis or as the galvanic cautery. Electrolysis is perhaps the most generally useful method at the disposal of the dermatologist for treating vascular nævi. In the case of small nævi it is ideal: if the nævi are large, its usefulness is limited by the fact that, since the area of vessels affected by each thrust of the needle is small, the sittings are long and must be repeated. The operation is performed in this way: A slender needle is attached by a suitable holder to the negative pole of a galvanic battery, while to the positive pole is connected an ordinary sponge electrode. The needle is passed into the nævus and the positive electrode applied to some convenient part of the body. The tissue immediately surrounding the needle soon commences to assume a whitish color, which gradually extends, and this, together with the amount of destruction occurring about the needle, will be the index of the length of time the current is to be allowed to pass. The depth to which the needle is to be passed, the number of insertions of the needle, and the strength of the current used must all be determined by the size and nature of the growth. Usually the current supplied by twenty cells of an ordinary battery is amply sufficient.

In *treating telangiectasis* the steps are similar to those described above. The needle is inserted into each vessel, and as the current passes the small red line changes to a white line, when the current is stopped.

The *galvanic cautery* is used chiefly in the large elevated nævi. A fine cautery-point heated to a dull red is thrust into the tumor at various points and in various directions. The effect can be judged only after healing from the inflammation that follows is completed. It is usually necessary to repeat the operation. In using either one of these methods strict antiseptic precautions should be observed.

Two other methods of treatment deserve mention—*vaccination* and the *method of Marshall Hall.* A small flat nævus may often be cured by introducing into it vaccine virus, just as in performing ordinary vaccination. By the "Marshall Hall" method a cataract needle is introduced at one edge of the nævus and is thrust through to the opposite side: it is almost withdrawn, and then pushed through at a little distance from the first puncture, and so on till the whole growth has been traversed by closely-set radiating punctures. By the cicatrix which follows the vessels are frequently shut off.

Lymphangioma.—By lymphangioma is meant a *growth made up of lymphatic vessels.* The form which most often affects the skin is *lymphangioma circumscriptum*, and even this is a rare disease. It usually makes its appearance in the early years of childhood, and may attack almost any region of the body. When fully developed the appearance presented is striking. One or more patches, varying in size from a silver dollar to an area larger than the palm, will be seen raised above the level of the skin. At the first glance the patches seem to be made up of small

closely-packed warts. The surface is uneven and rough in aspect, and varies in color from a dirty gray to black. On more careful examination the seeming warts are found to be really vesicles from a pinhead to a pea in size, and so closely pressed together that their form is very angular and irregular. The vesicles are very deep-seated, their roofs being formed of the whole thickness of the epidermis. Some of the lesions are semi-transparent, but the epidermis of others is so thick that the lesions are opaque: it is the predominance of such lesions that gives to the patch its warty look.

Small dilated blood-vessels can often be seen coursing over the vesicles. By a careful examination the impression is conveyed that the lesions are not vesicles in the ordinary sense, but rather that they are cavities deep in the skin filled with fluid. The lesions are firm, tough, and not easily ruptured. Around the edges of the main plaques are generally lesions that have thinner coverings, and therefore appear more as simple vesicles than those described. In color they may be pink, red, or yellowish. If one of the lesions be pricked, a variable amount of clear fluid containing lymphatic corpuscles escapes. This may amount to only a few drops or the discharge may last several hours. In some cases the part upon which the lymphangioma is situated is increased in bulk. Lymphangioma persists indefinitely, tending to increase slowly in size by the formation of new vesicles and plaques.

Some mention should be made of the acquired dilatations of lymph-channels to which the name lymphangiectasis has been applied. In its most frequent form it constitutes *elephantiasis*. (*Vide* Chapter I.) Aside from elephantiasis, lymphangiectases are rare. They are always the result of antecedent causes which it is often difficult to discover. It is probable that both an *acute* and a *chronic* form exist, but nearly all cases described belong to the latter class. As an example of the acute form may be mentioned Trelat's case,[1] in which eight days after an injury to the penis there occurred, besides an ordinary lymphangitis of the foreskin, prominent vesicles which discharged lymph.

Chronic lymphangiectases develop slowly, their progress sometimes being marked by paroxysmal erysipelas-like attacks, such as are frequently seen in elephantiasis. The lower extremities are usually attacked. The skin lesions consist of nodosities often arranged in rows corresponding to the course of lymph-vessels. The skin is glazed, œdematous, and of violaceous hue. The nodules, at first hard, break down and discharge lymph, with the consequent formation of lymph-fistulæ. Various secondary lesions accompany this condition, such as œdema, dermatitis, pachyderma, phlegmon, and lesions of the periosteum.

We know nothing of the ETIOLOGY of lymphangioma circumscriptum. The etiology of lymphangiectasis may be plain or obscure. In some cases it results from the pressure of tumors on large lymph-trunks. Other forms of obstruction to the circulation, such as result from a chronic heart or kidney lesion, may cause the disease. Long-continued simple irritation, such as might result from an in-growing nail or an ulcer, has been thought to act as a predisposing cause. Lastly, various parasites, such as the filaria, the tubercle bacillus, and the specific causes of glanders and syphilis, can localize themselves in the lymphatic vessels and cause the lymphangiectasis.

If the description given above of lymphangioma circumscriptum is

[1] Besnier and Doyon, *Mal. de la Peau*, p. 384.

borne in mind, there should be no difficulty in making a DIAGNOSIS. Lymphangiectases may simulate ulcers, indolent abscesses, or varicose veins, but the discharge of lymph, flowing spontaneously or purposely withdrawn, would decide the diagnosis.

The PROGNOSIS in all cases of lymphangioma must be regarded, as there is a tendency slowly to extend and to recur after removal. In lymphangiectasis the prognosis depends largely upon the cause of the dilatation of the vessels: if this is susceptible of removal, the lymphatic lesions may be cured. It is of importance to remember that the most scrupulous aseptic precautions should be taken in all operations upon the lymphatics, as septic infection has very often followed such operations.

In the TREATMENT of lymphangioma the only procedure is destruction of the growth. Where scarring does not matter, the *cautery* is the best method, as by it the vessels are sealed for some distance beyond the portion actually destroyed. When a limited area is involved and scarring is to be avoided, *excision* with the knife is advisable. Chemical caustics have not given good results. Whatever method is employed, the removal must be thorough or the growth will re-form. In lymphangiectases elastic support should be used as for varicose veins, and compression applied to prevent lymphorrhagia. If only a few superficial vessels are involved, they may be dissected out. In chronic cases with ulcers and fistulæ *deep cauterization* with such active agents as chloride of zinc or Canquoin's paste has resulted in cure. In cases where the lymphangiectasis is the result of tuberculosis of the lymph-vessels all sinuses as far as possible should be laid open, the diseased tissue should be removed, and the wound thoroughly cauterized with zinc chloride. In severe cases, with large growth of the bones and tissues and exhausting lymphorrhagia, amputation may be demanded.

Keloid and Hypertrophied Scar (*vide* Chapter XXVII. Group V.).—It is often of the utmost difficulty to make a clinical diagnosis between true *keloid* and the much commoner *hypertrophied scar*. The two affections are therefore classed together, and in many essential points they are identical. Alibert regarded the true keloid as a growth springing from the uninjured skin, but it is doubtful if an absence of a history of injury could be taken as implying the non-traumatic origin of keloid, since in many cases growths indistinguishable from keloid have followed injuries so trifling as to have been readily forgotten had not some accidental circumstance fixed the occurrence in the memory. True keloid may present itself as a single tumor or many may be seen upon the body. In a negro recently seen by the author there were hundreds of tumors scattered all over the body.

The tumor varies much in size and in shape, though, as a rule, the outline is more or less oval, the border of the growth jutting out over the integument, which has suggested the likeness of the disease to the paw of an animal placed upon the skin. The color is a glazed, white or reddish, and often small dilated vessels may be seen coursing over the tumor. In the negro the color is frequently of a darker hue than the surrounding skin. Keloid usually causes no subjective disturbance, but, on the other hand, pricking or burning is sometimes experienced, or even an intolerable neuralgic pain. Keloid may cease to grow after a time or it slowly but steadily enlarges, or, very rarely, it undergoes partial or

PLATE XVI.

KELOID.

complete involution. Keloid may occur upon any part of the cutaneous surface, but it is very commonly found over the sternum (Plate XVI.).

The *hypertrophied scar* differs from keloid clinically in that it does not spread beyond the limits of the orginal injury, and in fact often contracts into narrower bounds.

The true and intimate ETIOLOGY of keloid remains unknown. Certain races, notably negroes, are especially prone to it. The disease very commonly occurs where lesions of the skin have been produced, as by piercing the ears, or following acne, small-pox, or syphilitic eruptions.

Anatomically, true keloid consists of a dense connective-tissue new growth seated deep in the corium, most of the fibres being arranged parallel to the surface of the epidermis, and the papillæ over the growth being preserved. In hypertrophied scar the connective-tissue bundles are less dense, more irregular in their arrangement, while the papillæ are destroyed by the injury from which the scar resulted. Warren believes that the growth has its starting-point in the walls of the vessels.

In young subjects there is always some prospect that *spontaneous involution* may occur. As a rule, no operation demanding the use of the knife is permissible in true keloid, as there is a strong probability that the growth will recur. In hypertrophied scar, if deformity is caused or severe pain is present, removal may be necessary, but particular care should be taken that immediate union in the wound is obtained. The incision must be wide enough to embrace not only the scar, but also a portion of the surrounding tissue. Where there is not sufficient tissue to permit of this, skin-grafting by Thiersch's method should be employed at the time of the operation to cover in the defect. In this way recurrence will best be avoided.

All the methods of treatment which have had any success in keloid depend on *occlusion of the vessels* of the growth. Verneuil has strongly advocated pressure by the elastic bandage, taking care that no friction is produced which would tend to stimulate the growth. Vidal has employed with success deep multiple incisions, finely mincing the growth, the operation being several times repeated. The author has obtained some favorable results from electrolytic puncture; Brocq also urges this method. A weak current and many sittings are the requisites to success. This method is indicated only in small growths, and is most apt to succeed in hypertrophied scar.

Elephantiasis.—Elephantiasis is a malady due to the blocking of the lymph-channels, the most notable clinical feature of which is a hypertrophy of the skin and subcutaneous tissue. The disease occurs as an endemic in certain tropical countries, but in this country only sporadic cases are seen. The endemic form usually commences by attacks which much resemble erysipelas. There are fever and swelling and redness of a part, usually a lower limb. The lymph-vessels often become turgid, and on puncture emit a chyle-like fluid. In a short time the fever subsides and the swelling of the leg partially disappears, leaving the limb slightly larger than before the attack. It is by the repetition of such attacks that the endemic form of elephantiasis progresses. In the sporadic form nothing which corresponds to the elephantoid fever is observed, except in the cases occasionally seen where repeated attacks of erysipelas have blocked the lymph-channels.

If the disease is fully developed, it forms a striking picture. The leg is the member most often involved. The part is two or three times its normal size. The natural folds are increased in depth till they form fissures in the skin. In these crevasses is a slimy, offensive fluid formed by decomposing excretions and epithelium. The skin is frequently discolored, of a brownish or black hue. The surface may be smooth, or, on the other hand, covered with dilated lymph-vessels and presenting plaques of warty-looking hypertrophied papillæ. Ulcerations often occur, and not uncommonly open a lymph-vessel, so that lymph freely escapes. The surface is also subject to periodical eczematous inflammations.

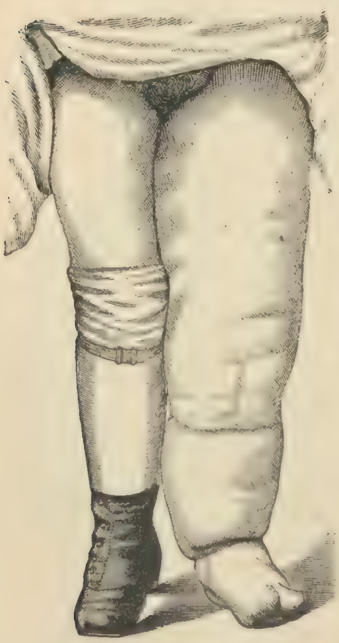
Next to the lower limbs, the genitals are most frequently attacked. In some cases the scrotum has attained such enormous proportions as to reach almost to the ground. Very rarely the arm, hand, or face has been found involved.

As a rule, there is no pain attending elephantiasis. The general health is unaffected, save by the restriction of movement and occasionally by the amount of the lymphorrhagia.

Etiology and Pathology.—Elephantiasis affects both sexes and all ages, but is most common in men. It may be congenital. It is most frequent among dark races. The affection is due to the blocking of the lymph-channels. In the endemic form the obstruction is due to the *filaria sanguinis hominis.*

Erysipelas, syphilis, phlegmasia alba dolens, tumors pressing on large lymph-trunks, may all result in lymph-obstruction and elephantiasis. The greater portion of the enlargement is found to be due to a growth of fibrous tissue in the subcutaneous layers. The corium is increased in thickness and the epidermis often proliferates. Lymphatics, blood-vessels, and nerves may be enlarged, as may the bones also.

Fig. 191.



Elephantiasis.

Diagnosis.—There is no other affection which is liable to be mistaken for elephantiasis.

Prognosis.—As far as health is concerned, the prognosis is good. The affection, if of long duration, will probably not be much benefited save where it is so situated that removal is possible. In the countries where the disease is endemic removal to another climate often improves the condition.

Treatment.—As far as general treatment is concerned, the indications must be drawn from the cause of the disease as well as its stage at the time of treatment. Thus, where a syphilitic origin can be suspected antisyphilitic treatment offers hope. If an endemic case is seen while in a febrile attack, a fever diet and attention to the general functions of the body are requisite. If a patient has been reduced by ulceration with lymphorrhagia, a nutritious diet and reconstituent remedies should be employed. In cases where it is possible, as about the genitals, *removal* is proper and

nearly always successful. *Ligation of the main vessels* supplying the part affected was once practised, but is not now advocated. Where the lower limb is involved the use of a properly-applied rubber bandage gives most relief. Galvanism has been used with success in some cases.

Myoma.—*Myomata* are new growths composed of fibrous tissue and muscle-fibre. They occur as a number of nodules more or less grouped, and also as single tumors. The variety in which the tumors are multiple is extremely rare. The tumors develop slowly, in the course of years attaining the size of peas or beans. When multiple they are usually grouped and appear only in one region of the body or in several limited regions. The lesions are of the color of the normal skin or pink or red, and are firm to the touch. Most of the cases have been spontaneously painful as well as tender on pressure.

The single tumors are more common; they occur chiefly on the mammæ of women and about the genitals of both sexes. The tumors are usually small, but may be as large as an apple. They will often contract on exposure to cold.

Myomata are supposed to originate from some of the muscles connected with the skin, as the erectores pilorum.

The DIAGNOSIS of myomata may be very difficult, and only a microscopical examination is to be relied upon.

The only TREATMENT is ablation of the growth, and this may be impossible in the multiple form.

Lipoma.—A lipoma is composed of fat-tissue. The growth is usually situated in the subcutaneous tissue, and may be single or multiple. Lipomata vary in size from a plum up to tumors weighing many pounds. A lipoma is very rarely congenital except in connection with lymphatic anomalies, but usually develops in adult life.

Although lipomata may occur upon any portion of the body, the commonest sites are the back and the buttocks. The skin over a lipoma is usually unchanged, but may be pigmented and covered with telangiectases. To the touch the tumor is soft and elastic, and it usually gives the impression of being lobulated. When the skin is made tense over the tumor, a peculiar dimpling is generally noticed, due to the adhesions of the fibrous septa of the tumor, which draw down the skin at certain points.

Lipomata are usually unattended by subjective symptoms, but where nerves are pressed upon neuralgic pain may be caused. The lesions are slow-growing, and frequently, having attained a moderate size, remain stationary. Anatomically, lipomata consist of masses of ordinary fat-tissue separated by fibrous septa containing blood-vessels. Lipomata of the skin are perfectly benign, and interfere with health only when their size becomes so great as to inconvenience their bearers.

The only TREATMENT of lipomata which merits attention is excision, and this should be undertaken only when the size or situation renders it necessary.

Fibroma.—Fibroma of the skin manifests itself by the presence of variously sized tumors made up of fibrous tissue. Clinically, at least two varieties of fibromata can be recognized. In the first a *small, firm, round tumor* is present covered by normal skin. As a rule, these little growths are single, and are most commonly found on the face, trunk, or extremities.

In the second form, known as *molluscum fibrosum*, the growths are multiple, hundreds being sometimes present upon the body. The tumors vary in size from a pea to masses weighing many pounds. The growths do not feel firm to the touch, but lax, and can be rolled between the fingers. The skin in the smaller tumors is normal in color, but upon the larger ones telangiectases are often seen, as well as more or less hyperpigmentation.

The smaller nodules are usually hemispherical, projecting from the skin, but as they increase in size they tend to become pedunculated. Upon some of the tumors one can see very large comedones. Among the other lesions will generally be found little empty sacs of skin from which the contents have been absorbed. Sometimes great folds of skin are formed, which hang down like a cape. This may occur without the ordinary tumor-formation. This condition is termed dermatolysis. This form of fibroma affects most commonly the trunk, then the back of the head, the face, and the limbs.

In the case of single tumors excision may be practised where there is sufficient reason, such, for instance, as pain from pressure on a nerve. With the multiple tumors it may become necessary to remove the larger growths or the pendulous masses of skin. In such cases the hemorrhage is often alarming on account of the large vessels, and the surgeon must be prepared to meet this emergency.

Neuroma.—Under the name *neuroma* authors have from time to time described tumors of the skin or subcutaneous tissue which were accompanied by more or less pain, often neuralgic in character. On microscopical examination such tumors have usually been found to be made up of fibrous tissue with some nerve-fibres.

It is a mooted question whether there is an actual increase of nerve-tissue in these growths: many believe that the tumor has only accidentally, as it were, involved the nerve. The author has reported a case which would certainly in a clinical way have been called a case of neuroma cutis, but a microscopical examination revealed that the little tumors were made up of small muscle-fibres, and no nerve-elements could be demonstrated.[1]

The only TREATMENT for all these cutaneous and subcutaneous nodules, whatever their nature, is excision. When there are large numbers of tumors present, it often suffices to remove those which are most painful.

Epithelioma.—Three forms of epithelioma are usually described, and, though this division is purely artificial, it is retained for convenience of description:

(1) The *superficial* or *discoid form* of epithelioma often commences as a small pearly or waxy-looking papule, upon the apex of which usually a few thin scales collect. On removing the scales after the lesion has existed for a time there are exposed red granulations. The papules may remain for years without any further change, but more commonly they become very gradually infiltrated at the base, while the top assumes more and more the character of an indolent ulcer. The amount of tissue destroyed by the ulcer is variable. Sometimes, after a course of years, the epithelioma has only eaten away a small area, involving no more than the tops of the papillæ of the skin, while in other cases great disfigurement and death may result from the amount of tissue lost.

[1] *Am. Journ. Med. Sciences*, April, 1886.

In this variety of epithelioma it is rare to find the lymphatic ganglia involved, except in the very latest stages of the disease. It is also a very rare occurrence to find other organs affected by metastasis.

(2) *Papillary epithelioma* is the name given to a form of epithelioma in which from the first there is a marked tendency to the formation of hypertrophied papillæ. This type of epithelioma is most prone to affect the border where mucous membrane and skin join, the mucous membranes, the extremities, and the scrotum. Not uncommonly the affection starts where a wart or other benign papilloma has existed for a long time.

Gradually the base of the simple growth becomes indurated, while the papillary formation becomes more marked till the papillary epithelioma is developed. When fully formed the tumor consists of a hard, infiltrated base which is covered with large florid granulations. The tumor often has the shape of a cauliflower or cock's comb. For a long time the growth of the epithelioma may extend peripherally, but in the course of time ulceration sets in, and, the hard, fibrous base giving way, the ulcer extends deeply, even attacking underlying bones. The ulcer when fully formed is characteristic, with hard, elevated, everted, purplish borders, the floor being covered with easily-bleeding granulations. The lymphatic ganglia in the neighborhood are often involved, especially in the later stages, and metastasis to distant parts may occur. The average duration of this form of epithelioma is said to be four years.

(3) *Deep-seated epithelioma* may develop as a recurrence after the removal of one of the other forms, or it may be a primary growth. It is the latter which is here described. The tumor occurs most often in the mucous membrane, and particularly the tongue. It occurs also upon the skin. This form of epithelioma commences as a small, hard nodule deep in the submucous or subcutaneous tissue. The growth enlarges, and the tissues covering it may for some time remain normal, but eventually adhesions occur, so that the skin or mucous membrane is no longer movable. The skin covering the growth is often florid and shows dilated vessels. After a variable time an ulcer forms, or the necrosis may occur more rapidly and a considerable portion of the growth may come away as a slough. A deep, irregular ulcerating cavity is left with hard edges. The progress of this form of epithelioma is more rapid than those already described, and sometimes in the course of a few months death may occur from dissemination or from marasmus.

FIG. 192.

Epithelioma.

Mention must be made of a form of epithelioma which goes by the name of rodent ulcer. It is now agreed by most dermatologists that the significance of this name is purely clinical, there being no pathological grounds for separating rodent ulcer from other epitheliomata. This form of the malady is said to commence usually as a small brownish, rather soft nodule, generally found upon the upper two-thirds of the faces of elderly persons. After this has remained quiescent for a long time ulceration occurs. Though ulceration progresses slowly, its ravages may in the end be extreme, as the disease remains purely local, and thus does not readily terminate the life of the patient. After the

affection has fully developed it presents the appearance of a crateriform ulcer with slightly everted edges, the great distinction of rodent ulcer being that the amount of induration is insignificant as compared to the extent of ulceration.

Etiology and Pathology.—Epitheliomata, like other forms of cancer, are most apt to attack those who have advanced beyond the middle of life, though it is probable that cancerous growths are more common in young people than was formerly taught. The *male* sex is much more frequently affected by epithelioma than the *female*. The factor which seems to be most potent is *long-continued irritation* of the epithelium in a certain region, as upon the lip by the pipes of smokers. Thus also is explained the cancer of the scrotum of chimney-sweeps and the epitheliomata of tar- and paraffin-workers. An epithelioma not uncommonly starts from a point which has been the site of some former pathological process, as a wart or a birth-mark or a scar. Epitheliomatous lesions frequently develop in the wake of the disease known as *xeroderma pigmentosum*. Cottrell believes that syphilitic affections of the tongue form an especially frequent starting-point for epitheliomata.

There is much reason to think that the true etiology of epithelioma is to be sought in some infective parasite, and the number of those who adhere to this view is constantly increasing. The parasite of cancer is regarded by most of those who believe in its existence as belonging to the class of protozoa.

Epitheliomata consist microscopically of masses of epithelial cells surrounded and separated by bands of connective tissue. In some cases the epidermis is disposed in irregular bands and masses or lobules. The cells in the centre of such masses often become corneous, and by pressure assume a peculiar laminated appearance, to which the term cancer-nest has been applied. In other cases the epithelium does not undergo the corneous change, and then presents an appearance more or less resembling gland-structure, consisting of epithelial processes surrounded by connective tissue, the epithelium often showing more or less of an attempt at a regular arrangement around the periphery of the processes. This last form of epithelioma is supposed by some to spring from the glands of the skin, but such an origin is probably rare. There has been much dispute among pathologists as to the true pathology of rodent ulcer. It is now almost universally acknowledged to be an epithelioma, opinion varying as to whether it is an ordinary epithelioma or an epithelioma springing from a sweat-gland or other structures.

Diagnosis.—As a rule, the diagnosis of epithelioma is easy. The age at which it develops, the chronic ulcer with indurated edges, and late in the disease secondary adenopathy, all help to establish the true nature of the affection. The maladies with which epithelioma is most apt to be confounded are *syphilis*, *lupus*, and *rhinoscleroma*.

A chancre might resemble an epithelioma, especially when it is found on the lower lip of an elderly man; but with the chancre there is a history dating back at most for only a few weeks, while that of an epithelioma covers months; in chancre the lymphatic ganglia are involved early in the course of the sore, but in epithelioma only at a late date; in chancre the induration is apt to be much larger in comparison to the ulcer than in epithelioma; and finally, if doubt still remains, it will be settled in a short time by the occurrence with a chancre of a roseola.

A gumma of the tongue might closely resemble a deep-seated epithelioma of that organ, but the course of the gumma is more rapid, there are other signs of syphilis, and the lymphatic ganglia are not involved, as they are at a very early date with this form of epithelioma. When the gumma has broken down, the ulcer left is more undermined at the edges than the epitheliomatous ulcer: it has not much, if any, infiltration at the base and edges, and does not show the fungous growths which are usually a conspicuous feature of epithelioma.

It is hardly likely that the ordinary form of lupus vulgaris could be mistaken

for epithelioma. There is, however, one form of cutaneous tuberculosis (*t. verrucosa*) which somewhat resembles the papillary epithelioma, but the situation of the lesion, the history, the absence of induration and of tendency to ulceration in tuberculosis verrucosa, and, finally, a microscopical examination, ought to decide the question. (*Vide* Chapter XXVI.)

The differential diagnosis of epithelioma and rhinoscleroma will be considered under the latter disease.

Prognosis.—Epithelioma is always to be regarded as of grave prognosis on account of the liability to recurrence after attempted removal, yet the outlook may be relatively good or bad. The prognosis is made worse by such circumstances as the situation of the growth on mucous membranes, by the early rapid growth of the tumor, by early lymphatic involvement; it is also rendered better if the growth is situated upon the skin where any operation for its destruction may be freely carried out, by the superficial character of the epithelioma and its slow growth, and by the absence of lymphatic involvement.

Treatment.—It may be said that it is exceedingly questionable if any treatment for epithelioma beyond the local treatment is of avail. Lassar has recently spoken of apparent cure effected by the internal administration of arsenic, together with the hypodermic injection of the drug into the tumor. Coley, and more recently Emmerich and Scholl,[1] have made use of injections of the toxins of the streptococcus of erysipelas in some inoperable cases of cancer with apparent cure, but as yet the method is in a strictly experimental stage.

The local treatment of epithelioma consists of *eradication, complete and thorough*. If the growth is so situated that an abundance of tissue can be spared, the knife is the most convenient mode of removal. The incision must be made, both in depth and circumference, wide of the apparently diseased area, so as not to leave any cancer-cells from which the malady can be reproduced. *Caustics*, when properly applied, form one of our most efficient modes of destruction of epitheliomatous growths. To be effective their application must be thorough, for used with a timid hand they are worse than useless, serving only to goad the cancer to more rapid growth.

A great many caustics have been used for the purpose of destroying epitheliomata. The most important are *arsenic, zinc chloride, pyrogallic acid*, and *caustic potash*. The first is the most generally useful, especially as it exerts a selective action, destroying the cancer-cells more readily than the healthy tissue. Its use has certain limitations. For instance, it cannot well be used on the mucous membrane of the mouth, for fear of poisoning, nor about the eyelids, on account of the impossibility of exactly controlling the amount of destruction caused by the remedy. It should always be made a rule for the physician himself to apply arsenic, and the patient should be seen at frequent intervals during the use of the drug. In the treatment of epithelioma arsenic is used most frequently in the form of a paste. There are a number of such pastes in use, but the one preferred by the author is that introduced by Bougard. The formula for it is—Wheat flour, starch, *āā*. 30 grammes; arsenic, 0.5; hydrarg. sulph. rub., 2.5; ammonii muriatis, 2.5; zinci chloridi, 30; hot water, 45. The first six ingredients are finely powdered, and then the zinc chloride, dissolved in the water, is added while the powder is stirred.

In practice a portion of the paste is spread on a cotton cloth large enough to extend slightly beyond the cancerous sore. This is applied and allowed to remain on twenty-four hours. It is a good plan to see the patient within twelve hours, as the action of the paste is more rapid in some cases than in others. There is a

[1] *Deut. med. Woch.*, April 25, 1895.

notable difference in the sensations of patients during the use of this paste, some complaining of excessive pain, others speaking of it as trifling. The result of the application is the formation of a *slough* involving the epithelioma and quite a severe inflammatory reaction in the surrounding tissues. This inflammation has the advantage that it is very likely to act in an unfavorable way upon any outlying cancer-cells which have escaped actual destruction. Under poultices such as the unguentum vaselini plumbicum spread on cloth the slough soon separates, leaving a healthy granulating cavity which usually rapidly cicatrizes. Should any of the epitheliomatous tissue have escaped the first application, others should be made as soon as the fact is ascertained. The *zinc chloride* alone may be used in a similar way as a paste.

Pyrogallol is a remedy which is appropriate for small growths. It is advisable first to scrape away the epithelioma with the curette, and then apply for several days a 25 per cent. ointment of pyrogallic acid, putting on fresh ointment each day.

Caustic potash is used in the stick form. This is bored into the tissues till the requisite destruction is accomplished, and then the further action of the caustic is stopped by applying a weak acid.

The *galvano-cautery* may be very well used in the destruction of epitheliomata, especially when small ones are to be dealt with.

Darier[1] has recorded cures from the following method: The tissue is first cleared of all crusts. Then a solution of one part of *methyl blue* to ten parts of a mixture of equal parts of alcohol and glycerin is applied. The cancer-cells are stained blue, and to these masses a 5 per cent. chromic-acid solution is then applied. This process is repeated at frequent intervals.

The list of the various procedures which have been recommended in the treatment of epithelioma might be almost indefinitely prolonged. The sum of the whole matter is, that to-day the proper treatment is destruction. The means we adopt for this purpose will depend on the size and situation of the growth and the willingness of the patient to consent to the advice of his surgeon.

Paget's Disease (*vide* Chapter XXVI., Group VII.; also Chapter XIV., Vol. II.).—*Paget's disease* most frequently attacks the *breasts* of women in the middle period of life, but it may affect other parts of the body, and the male sex as well. Crocker has seen it upon the *scrotum*, and a case has been reported in which the affection attacked the *nose*. The malady usually begins upon the *nipple* of one breast, and looks at first like an ordinary eczema. There is more or less crusting, and when this is removed a raw, red granular-looking skin is exposed from which exudes a glairy secretion. The area involved slowly extends, the border remaining sharply defined and often a little raised. The base of the inflamed skin usually presents a thin infiltration, and scattered over the surface a few small islets of a pearly-looking epidermis can often be seen. It is common to find the nipple gradually retracting. The malady may not extend much beyond the nipple or it may attack the skin of the whole breast. In a case recently seen the skin of a large portion of the anterior aspect of the thorax had become affected.

There are itching and burning from the beginning. At the end of a few months, or in some cases only after many years, the disease enters upon its last stage, that of cancerous degeneration. This manifests itself either by the appearance of epitheliomata on the affected area or by the formation of an ordinary scirrhus of the breast.

Microscopical examination of the affected skin shows that the superficial layers of the epidermis are thinned or wanting, while there is a decided down-growth from the deeper layers, and in some places alveoli of epithelial cells can be found. Thin states that the first cancerous changes occur in the lactiferous ducts. Darier has recently described

[1] Brocq, *Journ. Cut. and Gen.-urin. Dis.*, Oct., 1894.

certain bodies which may be seen in the epidermis in Paget's disease. These bodies are two or three times the size of the surrounding epidermic cells, and consist of a double-contoured cell-wall, within which is a mass of protoplasm containing several nuclei. Darier supposes that these bodies are psorosperms, and that the irritation of their presence causes the changes noted. The bodies may be found in scrapings which have been soaked in liquor potassæ.

The importance of an early DIAGNOSIS cannot be over-estimated. The affection which Paget's disease most resembles is *eczema of the nipples*. Paget's disease usually develops after the menopause, eczema during lactation. The surface exposed on removing the crusts in Paget's disease is of a brighter red and more granular than that of eczema, while the border is more sharply defined. In eczema there is not the infiltration noted in Paget's disease, and scrapings do not show the peculiar bodies described above.

TREATMENT.—When seen in its early stages or before the diagnosis can be established soothing applications should be made just as though one were treating an eczema. When we are quite sure of the nature of the malady, *energetic treatment* should be resorted to. We may scrape away the diseased tissue with the curette and then apply a strong (30 per cent.) solution of zinc chloride for several hours, afterward dressing antiseptically. A zinc-chloride paste may be used instead of the solution, or an ointment containing 30 per cent. pyrogallol may be applied for two or three days until a sufficient destruction has been accomplished. When malignant growths have formed excision of the whole breast must be performed.

Carcinoma Cutis.—Besides epithelioma, there are two varieties of carcinoma of the skin—the *lenticular* and the *tuberose* forms. Some authors recognize a pigmented form also, but it is to-day generally thought that most of these cases are really sarcomata.

Lenticular Carcinoma.—Lenticular carcinoma nearly always develops secondarily to a primary carcinoma; for instance, of the breast. The first evidence of the affection is the appearance of a number of white or pale-pink papules of a firm consistency, from a shot to a pea in size. The skin upon which these papules are situated may retain its normal color or may be of a violaceous hue and present dilated capillary vessels. The papules gradually increase in number, and coalesce to form larger nodules and plaques. In some cases large areas of skin become thickened and hard, constituting the *cancer en cuirasse.* The lymphatics may be so obstructed by the growths that the limbs become much swollen. The patient falls into a state of profound cachexia, and usually dies in a comparatively short time. If life is sufficiently prolonged, some of the nodules may ulcerate and fungous granulations may form. In a case of the author's the microscope showed that the nodules were made up of masses and bands of epithelial cells lying apparently in the lymphatic spaces of the skin.

Carcinoma Tuberosum.—This form of cutaneous cancer is rarer than that just considered. It occurs upon any part of the body in the form of hard, nodular masses from a marble to a small apple in size, and of a brownish or purplish color. There are usually many such nodules on the body. In a case of the author's there were fully a dozen nodules

situated upon a dense mass lying in the subcutaneous tissue of the back, and conveying to the finger the sensation that a flat mass of wood was being felt through the skin. The tendency of the tumor is to break down into fungating ulcers which rapidly exhaust the strength of the patient.

All TREATMENT, thus far, has proved futile in carcinoma cutis, and the only ray of hope for such patients lies in the suggestion noted under Epithelioma, that some cases of malignant cutaneous growths seem to have been cured by the toxines derived from the erysipelas germ.

Sarcoma Cutis.—Sarcoma of the skin presents so many clinical varieties that it is extremely difficult to give a general description of the affection. Cutaneous sarcoma may be primary or secondary; one tumor may be present or many; the growth may be pigmented or non-pigmented.

Melanotic Sarcoma.—This is the most frequent form of sarcoma, and usually has its origin in a pigmented mole. From the mole a spongy,

Fig. 193.

Fibro-sarcoma of hands.

fungating, black tumor develops. In the course of a few weeks or months, generally first in the neighborhood of the original growth,

numbers of small, firm, pigmented masses appear. These small tumors coalesce into large masses, ulceration occurs, the lymphatics become involved, and, after having become more or less generalized over the skin, the sarcoma attacks internal organs. The course of this form of sarcoma is usually rapid. Hutchinson has described a special form of melanotic sarcoma under the name *melanotic whitlow* which commences as a *chronic onychitis* with a faint pigmentation; gradually a slightly pigmented, fungating tumor develops, and then the sarcoma becomes generalized. Histologically, these tumors are very vascular round or spindle-cell sarcomata, with giant cells in some parts of the growth. There is also always more or less pigment to be seen both in and between the cells.

Idiopathic Multiple Pigmented Sarcoma.—This form of the disease was first described by Kaposi: it is very rare. It generally occurs in middle-aged males, and first manifests itself as reddish-brown or plum-colored, pea-sized tumors, which are tender on pressure and are accompanied by spontaneous pain. The growths occur on the flexor or extensor aspects of the hands or feet. The tumors increase in number and run together to form plaques. In addition to this, the hands, feet, and eventually the limbs, fall into an elephantiasic condition on account of a diffuse, board-like infiltration in the skin.

The tumors rarely ulcerate, but they often undergo involution, leaving pigmented scars. In the course of two or three years the tumors have usually begun to develop upon the face and trunk. After this the downward course is more rapid. The tumors may form upon the mucous membranes. Sooner or later dysenteric symptoms, hæmoptysis, fever, and marasmus terminate the scene. After death the internal organs, and especially the large bowel, are found to contain nodules similar to those in the skin. Histologically, this form of growth looks like a small-cell sarcoma into which many hemorrhages have occurred. The pigmentation is due to the hemorrhage, and really it would be more correct to class this affection among non-pigmented sarcomata. Multiple pigmented sarcoma may in its early stages very much resemble a large papular syphilide, except for its more limited distribution. In the later stages some cases bear a resemblance to the affection known as *mycosis fungoides.*

Non-pigmented Sarcoma.—Non-pigmented sarcoma may be multiple or single, primary or secondary to a malignant growth of some internal organ. The tumors may be seated in the subcutaneous tissue or in the skin itself. The skin is sometimes normal in color, but more often of a bluish hue. Several tumors may run together to form large plaques, followed by ulceration. The disseminated form of non-pigmented sarcoma seems to be far less malignant than the pigmented form.

Localized non-pigmented sarcomata of the skin may follow a blow or develop from a nævus or other skin-lesion. The growth rarely attains a size larger than an orange. The skin over the tumor may be normal in color or of a darker hue. After a variable time ulceration occurs, and secondary tumors form in the skin, viscera, or lymphatics. It should be mentioned that in both *leukæmia* and *pseudo-leukæmia* tumors and plaques of infiltration, *sarcomatous* in their histology, may develop in the skin and other organs.

The TREATMENT of pigmented sarcomata after dissemination has occurred is futile. If the primary growth is removed thoroughly at an early date, there may be some chance of cure. No treatment has suc-

ceeded, in the great majority of cases, in curing idiopathic multiple pigmented sarcoma, but the author has seen a case recover spontaneously, and Kohner claims to have brought about a cure by the use of arsenic. Arsenic administered hypodermically in gradually increasing doses has cured a number of cases of multiple non-pigmented sarcoma. The local sarcomata should be removed as soon as the diagnosis is made. Reference has already been made to the employment of erysipelas toxines in carcinoma. It has been used apparently with some benefit in inoperable cases of sarcoma.

Tuberculosis of the Skin.—To-day no one doubts that the tubercle bacillus is capable of causing grave troubles in the skin. It is still a question as to where the limit of the various clinical forms which are in reality tuberculous should be drawn. Already it is shown that most cases of what was called papilloma are in reality tubercular infections. The same has been shown for many apparently simple chronic ulcers. Many are contending to-day for the tubercular nature of *lupus erythematosus*, and there can be no doubt that there are cases of tuberculosis of the skin which are clinically indistinguishable from it. (*Vide* Chapter IX.)

At present there are at least four well-recognized clinical forms in

FIG. 194.

Lupus vulgaris.

which tuberculosis of the skin may occur; *Lupus vulgaris, tuberculosis cutis, tuberculosis verrucosa*, and *scrofuloderma.*

Symptomatology.—*Lupus vulgaris*, as a rule, commences in childhood and upon the face. Often the first evidence of the disease will be two or three small red-brown spots upon the cheek. They may be slightly raised, on a level with the skin, or depressed. Slowly these spots enlarge and take on a semi-transparent "apple-jelly" look. These are the well-known lupus tubercles, and it is by variations in their size and course that all the clinical manifestations of lupus are formed. The tubercles are much softer than the surrounding tissue, as may be ascertained with a blunt probe. Gradually more and more tubercles appear, and in the course of months, or more often years, by coalescence, a brown-red patch is formed, somewhat raised, thickened, and covered with a certain amount of thin scales. In the border of such a patch it is nearly always possible to distinguish typical lupus-tubercles. From this point the lupus pursues one of two courses. It may *break down and ulcerate.* This is especially liable to happen when any of the mucous orifices are involved in the ulceration: all the soft parts down to the bone may be destroyed, but the bones are hardly ever attacked. The ulcers heal, usually after having existed for a long time, and scars of various sorts, from a thin to a much-banded scar, result. After the apparent healing has lasted a long time it is very common to see lupus-tubercles again making their appearance in the scarred area, and the process again runs through the course described. While the ulceration is going on at the central portion of the patch the border has been slowly extending by the growth of new tubercles.

In *some cases* or in some parts of a patch *ulceration does not occur*, but interstitial absorption in the lupus-tissue occurs, and gradually the area becomes atrophic, covered with the scaling epidermis, and depressed below the surrounding level.

Lupus may affect any part of the body, but the scalp, upper eyelids, forehead, palms, and soles are notably exempt.

There are certain clinical variations to which descriptive terms have been attached. When the borders of two or more contiguous patches join in a serpentine figure, the appearance is called lupus serpiginosus. If the surrounding parts are affected with a sort of elephantoid state, or if the margin of the patch is much raised, it is spoken of as lupus hypertrophicus. Sometimes the lupus ulcer becomes filled with fungoid granulations—lupus papillaris verrucosus. Leloir has described a form of tuberculosis of the skin under the title lupus vulgaris erythematodes which very closely resembles lupus erythematosus. This clinical type should not be forgotten: it is not uncommon; the author has seen several cases.

Quite frequently lupus attacks the mucous membranes, spreading from the adjacent skin. Lupus of the nose sometimes starts in the mucous membrane of the nares, where it occasions crusting, being mistaken for eczema, and its true nature becoming manifest only after it has spread to the skin. Owing to the nature of the tissue, lupus of the mucous membrane does not present lupus-tubercles, such as are seen in the skin, but this lesion is replaced by a papillary growth. These growths form plaques which may undergo absorption or ulceration, just as happens in the skin.

Tuberculosis Cutis.—The affection to which this appellation has been given has been seen only in persons affected with tuberculosis of some internal organ, and is rare. The disease occurs as chronic ulcerations at muco-cutaneous junctions, as the mouth or anus. The ulcers are shallow, with ragged borders. The floor is filled with granulations which secrete a thin, purulent material which may dry into crusts. At times small yellow miliary nodules can be seen scattered over the lesion.

This form of cutaneous tuberculosis does not always come on late in the course of the general infection, but may at times be one of the earliest signs, and some cases of ulcers of this class have been reported in which the skin-trouble seems to have been primary and tuberculosis of internal organs secondary. Often these ulcers are extremely painful. They may continuously enlarge, or, having reached a diameter of an inch, stop there. They show no tendency to heal.

Tuberculosis Verrucosa.—This affection was formerly known as *verruca necrogenica.* It occurs usually upon those who handle dead persons or animals or those who have come in contact with the secretions of patients affected with tuberculosis. The early appearance of the lesion may vary considerably, but as it develops a marked tendency to papillary hypertrophy is noted. The common sites of the affection are the knuckles, backs of the hands, elbows, and knees. In a well-developed lesion which is still extending there is an erythematous zone outside the patch. The patch is covered with a crusty-looking growth, often with pustules between the excrescences. The area may be small or it may be large enough to cover the back of the hand. There is little tendency to ulceration. Sometimes spontaneous involution occurs, but usually the lesion slowly extends. At times the centre becomes atrophic, while the circumference is still extending. Beyond the local trouble this form of tuberculosis is not, as a rule, serious, but a few cases are reported in which generalization occurred. The course of the affection is very chronic, the lesions frequently lasting many years.

Scrofuloderma.—This term is applied to certain lesions originating in the subcutaneous tissue in scrofulous subjects, and involving the skin secondarily. The lesions usually commence in lymphatic ganglia, especially those of the neck. A doughy, painless swelling is formed. After a time the skin assumes a bluish hue, and finally breaks at one or more points, giving exit to a sanious material and leaving an ulcer with ragged, undermined edges. At other times the origin is not from a lymphatic ganglion, but from a nodule in the subcutaneous tissue. The ulcer is extremely slow in healing, and may last for years. In some cases the patient is exhausted by the protracted suppuration, more especially as accompanying this condition there are usually other affections present to which the strumous are liable. After the ulcers have healed scars remain, usually traversed by bands and ridges.

Etiology and Pathology.—The active agent in the causation of all the forms of tuberculosis of the skin is the tubercle bacillus. It is likely that this nearly always gains entrance into the tissues by inoculation after birth, so that heredity plays a less prominent part in our ideas of skin-tuberculosis than it once did. It is nearly always in children that we see lupus developing, but too much stress must not be laid on this point, as it may first appear in the late years of life. According to the observation of Leloir, pulmonary tuberculosis forms a frequent complication of lupus, though this is denied by many authors.

In all forms of cutaneous tuberculosis we find histologically certain elements. These are the *tubercle bacilli* and the *nodules* of *granulation-tissue* containing *giant cells.* In tuberculosis verrucosa there is a hypertrophy of the papillæ and a corresponding thickening of the epidermis.

Diagnosis.—Although the recognition of a typical case of lupus vulgaris ought to be very easy, yet a great deal of confusion prevails, if we judge by the number of cases of epithelioma and other affections in which a diagnosis of lupus has been erroneously made. The cardinal points to bear in mind are—the *origin*, usually in *childhood*, the *great chronicity* of the affection, and the presence of the characteristic soft *lupus-tubercles*, which are nearly always found at the periphery of the involved area. The *differential diagnosis between lupus* and the late *syphilides* is perhaps most difficult. The syphilitic ulcer runs a much more rapid course than does lupus, often doing more damage in a few weeks than lupus does in as many years. The edges of the syphilitic ulcer are apt to be more sharply cut. It is common to find multiple syphilitic lesions, while usually but one patch of lupus is present. Syphilis often attacks bones, and the lesions are often covered by large, thick crusts and give rise to an offensive discharge. The history of a previous infection or of previous syphilides can frequently be obtained with the syphilitic affection. Finally, with antisyphilitic treatment the lesions of syphilis heal readily. The ulcer described as tuberculosis cutis can be distinguished from syphilis by the fact that it occurs in persons suffering from tuberculosis of internal organs, that it is very chronic, and that it often presents scalloped borders.

None of the tubercular lesions should be mistaken for epithelioma if we remember the peculiarities of the latter affection, its hard and everted borders, and the age at which it occurs. The microscopical examination would decide the question.

It may be a matter of great difficulty at times to decide as to the true nature of verrucose tuberculosis of the skin. It may somewhat resemble a patch of eczema, but the tuberculosis verrucosa is more chronic, more abruptly defined, and presents ulceration and scarring, which are never seen with an eczema.

A word may be in place as to the *value of the tubercle bacillus* in *diagnosis* of skin-tuberculosis. When it can be demonstrated, it is of course conclusive evidence, but a failure to find it cannot be considered as negativing the diagnosis, since it occurs in very small numbers, and thus easily escapes detection.

Prognosis.—All forms of skin-tuberculosis are characterized by a tendency to recurrence even where a cure seems to have been effected. This is especially true of lupus. Tuberculosis verrucosa and scrofuloderma give a better hope of permanent cure. If left alone, lupus nearly always slowly extends, causing hideous deformities, but rarely complete involution has occurred. The prognosis of tuberculosis cutis is that of the tubercular affection which it complicates.

Treatment.—Since it is almost universally admitted that tuberculosis of the skin is acquired by direct inoculation, it becomes of the highest importance to use every prophylactic precaution, especially with those who are supposed to be predisposed to tuberculosis. This includes avoidance of exposure, careful attention to all wounds, especially when they are known to have been exposed to tuberculous secretions, and careful and prompt cleansing of the unbroken skin when it has come into contact with any tuberculous matter.

Internal treatment can be of avail only in so far as it improves the general condition of the patient. In this way climate also may exercise a beneficial effect.

Thus far, we have no specific treatment. *Tuberculin* has been by

many discarded. *Thiosinanim*, much lauded in certain quarters, has proved inefficient in the author's hands. The true treatment of skin-tuberculosis is *local*.

Caustic agents have been used for a long time in the treatment of lupus. This method is not so much used now as surgical means. Only a few of the caustics will be mentioned here. Arsenical pastes (such as Bougard's, for which see Epithelioma) are valuable because they have a selective action, destroying diseased tissue more rapidly than the healthy. The paste should be applied on cloth, removed in twelve hours, and applied again if necessary. Pyrogallic acid has a selective action, and may be used in an ointment, ʒj to ℥j, spread on cloth and applied fresh twice a day till a sufficient effect has been produced. Nitrate of silver is useful, and with some dermatologists it is the favorite caustic; the solid stick should be used, boring it into the soft lupus tissue. Pure *lactic acid* applied to ulcerated lupus on lint, the surrounding skin being protected by an ointment, has frequently yielded excellent results: the applications last half an hour, are frequently painful, and must be repeated. *Salicylic acid*, either in plaster mulls with creosote added, as recommended by Unna, or made into a paste with glycerin, often gives good healing, especially in the more superficial forms of the disease. Elsenberg[1] has reported favorable results from the use of *parachlorophenol*. The area affected is first washed with alcohol and ether, and then pure parachlorophenol, heated till it melts, is painted on: this is somewhat painful. An ointment composed as follows is then applied: Parachlorophenol, lanolin, vaseline, powdered starch, *āā*. ʒiiss.—M. After ten or twelve hours this is removed and an iodoform salve substituted. In two days the parachlorophenol may be applied again, and so the treatment continued till cicatrization occurs.

Of the various *surgical methods* of treatment, *excision* is the one which theoretically should yield the best results, but its use has been restricted in past years on account of the large wounds which it necessitates. *Thiersch's skin-grafting has done a great deal to obviate this difficulty*. This is the best treatment for tuberculosis verrucosa and for the enlargements of the lymphatic ganglia which lead to scrofuloderma. The method which is most generally used in treating lupus is no doubt *curetting*. A sharp spoon is used, and all the lupus tissue is scooped away as thoroughly as possible: the surface should then be cauterized with carbolic acid or zinc chloride. A great portion of the affected area usually heals after such a procedure, but some nodules will appear again, and must be scooped out again or treated in some other way.

Multiple incision of the lupus area has been strongly urged by Vidal. The incisions should be made very close together, and usually two series of cuts are made at right angles. The theory of cure by this method is, that the vessels which nourish the new tissue are destroyed. The operation must be frequently repeated, and generally produces healing in a large part of the patch. The few remaining nodules are usually best treated in some other way.

The *actual* or *the galvanic cautery* may be used with advantage after curetting in place of a chemical caustic. This method may be also primarily used to destroy the lupus tissue either by puncture or by scarification. It is of special value in treating single lupus nodules. The galvanic cautery forms an excellent means of destroying tuberculosis verrucosa and for cauterizing the ulcers of scrofuloderma.

Electrolysis forms a convenient method for destroying nodules that have formed in the scars after any of the above-mentioned methods. A needle, affixed to the negative pole of a twenty-cell galvanic battery, is repeatedly thrust into the nodule till its destruction seems accomplished.

In treating an ordinary case of lupus it often happens that we get the best and most rapid results by a combination of these methods, using at some stage, for example, a chemical caustic, and then one of the sur-

[1] *Med. Week*, July 20, 1894.

gical procedures, or *vice versâ:* what combination of procedures is best for each case must be determined by the judgment of the surgeon.

The *treatment of the ulcerous lesions of scrofuloderma* will depend somewhat upon the condition of the patient, as well as upon the nature of the disease. It is advisable, if possible, to curette the ulcers, to lay open all sinuses, to cauterize with carbolic acid or chloride of zinc, and then to dress with iodoform. Where such severe means cannot be undertaken, the ulcers may be dressed with a paste made of salicylic acid and glycerin, to which has been added 1-2 per cent. of carbolic acid. Chaulmoogra oil internally and also as an ointment is recommended by Crocker.

Erythema Induratum.—Under the title *erythème induré des scrofuleux* Bazin has described a malady which most often occurs in young girls of a scrofulous habit. The disease first manifests itself as one or several hard, pale indurations in the skin, which can be more easily felt than seen. The indurations are most usually found on the legs, and a favorite site is just below the bulge of the calf. When a number of lesions are present they may coalesce into brawny patches. In the course of time the skin over the nodules becomes red and then violaceous. Involution may occur after a considerable time, or the indurations slough out, leaving deep indolent ulcers, which are very slow in healing. There are no symptoms of constitutional disturbance, but there are often severe pains in the limbs. Its chronicity, the small number of lesions present at first, and the absence of fever distinguish this affection from erythema nodosum. The disease is most often mistaken for syphilitic gummata, but the absence of a syphilitic history, absence of other syphilides, the evolution of the disease, and finally the failure of specific treatment, should determine the diagnosis.

In the way of TREATMENT all these cases demand tonics, cod-liver oil, and good hygiene. The patient should be placed at rest with the legs elevated. When ulcers have formed, dressing with stimulating powders, such as iodoform, and the application of antiseptic dressings with firm bandaging. are most appropriate. In any case the healing is slow.

Rhinoscleroma.—Rhinoscleroma is a *parasitic* lesion commencing as a painless induration, usually situated at the edge of the *alæ nasi* or upon the *upper lip.* It grows very slowly, and there is no tendency toward involution. The skin over the growth may be unchanged or it may present dilated blood-vessels or may have a dark reddish color. To the touch the mass has a peculiar wooden hardness. The tumor has a lobulated appearance. Between the lobules the skin may crack, giving exit to a thick yellow discharge which dries into crusts. The affection may occur in the palate, pharynx, or trachea. It causes usually no subjective sensations, unless by its increase in size it interferes with respiration. In some cases pressure on the growth causes exquisite pain. The disease is rare, but in some portions of Russia is almost endemic.

Anatomically, the growth is granulation-tissue, scattered through which are very large cells: in these cells short, thick encapsulated *bacilli* are found. These are the specific cause of rhinoscleroma. The long duration of rhinoscleroma, and the fact that it shows no tendency to break down, distinguish it from other growths with which it is apt to be confounded, such as syphilitic nodules or epithelioma.

There is little encouragement to operative interference, as thus far after removal the growth has always recurred. Lang seemed to get good results in one case by the internal administration of salicylic acid, and at the same time injecting the drug into the tumor. In case respiration is interfered with, a part of the growth may be removed or a hole may be drilled through it to permit breathing. (*Vide* Fig. 19.)

Actinomycosis.—Actinomycosis is another parasitic disease rarely involving the skin primarily. (*Vide* Chapter VIII.) The affection is most commonly seen in the *subcutaneous tissue of the jaws*, though other regions may be affected: for example, in certain tropical countries one variety of actinomycosis is not uncommon affecting the feet, constituting the malady called podelcoma. After an incubation-period which is not determined, the disease commences as one or more hard, *lumpy tumors* about the jaw. As they enlarge and approach the surface the skin over them become violaceous in appearance, and finally breaks down, often at several points. The sinuses thus formed discharge a sanious pus, floating in which may usually be found the actinomycotic granules, small, yellowish bodies composed of the ray fungus.

The malady is of extreme chronicity, and as a rule the health is not deteriorated, as it would be in the case of a malignant growth of the same size. The lymphatics are not involved. The affection sometimes becomes generalized by breaking into a blood-vessel.

The disease is most likely to be *mistaken for sarcoma*, from which it can be differentiated by the demonstration of the actinomycosis or ray fungus. For this purpose it is easiest to examine the granules. The fungus consists of a dense network of fine mycelia, scattered in the interstices of which are many coccus-like bodies. The extremities of some of the mycelia are expanded into club-shaped masses: this was once thought characteristic of the parasite, but is now regarded by many as simply the result of a degenerative change. It is supposed that the fungus frequently enters the body through carious teeth.

Not long since it was thought that the only TREATMENT consisted in total extirpation of the diseased tissue. Where this was impossible incision of the sinuses, with subsequent scraping and cauterizing, was recommended. Recently it has been shown that potassium iodide, administered as in syphilis, is almost a specific, and a number of cures by this means have been reported from various parts of the world.

Cysticercus Cellulosus Cutis.—The cysticercus of the tænium solium is occasionally found in the subcutaneous tissue, where it forms tumors from a pea to a marble in size, round, and covered by unaltered skin. In the early stages the tumors are tense and elastic, but in time may undergo calcareous change. Usually several tumors are found, most commonly on the back.

The DIAGNOSIS is often impossible to make except by removing one of the tumors and puncturing the sac and examining the fluid for the hooklets. Echinococcus-cysts have been found in the skin, where they form fluctuating tumors.

Guinea-worm (Filaria Medinensis).—The Guinea-worm is a white worm one-tenth of an inch in diameter and from two to three feet long. It is found in a great many tropical countries. The embryo probably enters the body in the drinking-water, and passes from the intestines to the skin, under which it develops. This applies only to the female worm, the male never having been discovered. When fully developed the

worm can be felt like a string coiled up. Inflammation more or less intense is excited, and a *vesicle* forms which breaks, allowing the *head of the worm to protrude.*

Sometimes the reaction set up by the parasite is violent, resulting in phlegmon or even gangrene. This is said to be common when the worm has been broken in attempted extraction. Worms have been seen in almost all parts of the body, but by far the largest number have been found in the foot. Usually a single worm exists in an individual, but sometimes many are present.

The time-honored TREATMENT for Guinea-worm consists in gentle traction performed by winding as much of the worm as protrudes each day about a bit of stick. This method is tedious, and recently means which would seem better have been suggested. Christie has recommended the destruction of the worm while still under the skin by electrolysis. Emily[1] recommends injecting into the worm as it lies under the skin a solution of bichloride of mercury. The worm is killed and absorbed without further trouble.

Perforating Ulcer.—The so-called *perforating ulcer* is probably nearly always secondary to some nervous lesion which involves the integrity of the trophic function. (*Vide* Chapter IV.) It is most commonly seen with *tabes dorsalis, leprosy,* and *syphilis.* The appearance of the lesion varies. It is nearly always a sinus. Sometimes the orifice presents a bunch of flabby granulations, while at other times there is about it a dense ring of hypertrophied epidermis like a corn. The lesion is usually seen on the foot and at points where pressure is naturally greatest, as the metatarso-phalangeal joint of the big or little toe. This suggests that the ulcer may be caused by traumatism. Very frequently the sinus leads down to dead bone, and joints are often disorganized. Usually there is no pain attending a perforating ulcer and the region around may be anæsthetic.

The COURSE of the disease is slow. If rest of the part is secured, it will heal, but breaks out again on using the foot.

The only affection which resembles perforating ulcer is a suppurating corn, but in the latter there is pain and the skin about it tender, and, besides, it readily heals.

The TREATMENT of this affection is unsatisfactory. Healing may be accomplished by rest and the use of stimulating antiseptics, but if the foot is used the disease is almost sure to recur. Amputation of the foot has succeeded, but sometimes the ulcer reappears in the stump. *Stretching the nerves* which supply the part, together with free opening of the sinus, has been recommended and used in cases where the malady affected lepers.

Onychia.—The term *onychia* is applied to any *inflammation of the nail-matrix.* The inflammation may be associated with some lesions of the nervous centres, as in Morvan's disease. There is an onychia which is of *syphilitic origin.* The most important and the only phase of the affection that will be discussed here is *onychia maligna.* This is an acute phlegmonous inflammation of the matrix which is most commonly seen in ill-nourished children of strumous habit. The affection commences with throbbing pain in the finger. There is a sero-sanguinolent exudation under the nail, which becomes of a dull, opaque color, is lifted from

[1] *Arch. de Méd. nav.*, June, 1894.

its bed, and curls up at the edges. It usually separates, leaving a sloughy surface which cicatrizes with the formation of a deformed nail. The inflammation may spread to the tissues about the nail, constituting a *paronychia*, which may result in the loss of the last phalanx.

The TREATMENT consists in such general measures as the condition of the patient demands, together with appropriate local applications. At first cold-water compresses give relief. As soon as fluid has collected beneath the nail the pain is best relieved by splitting the nail: if it is loose, it should be removed, as recovery is thus hastened. The surface left is to be treated with antiseptic dressings on ordinary surgical principles.

CHAPTER XXVIII.

BURNS, SCALDS, AND FROST-BITES, AND THEIR TREATMENT.

By John Parmenter, M. D.

Burns and Scalds.

To the old classification of burns and scalds, which regarded the depth only of the destructive effect, should be added another which takes cognizance of the superficial extent as well. It is a well-known clinical fact that a *deep burn of limited* extent is far less serious than one quite *superficial, but covering a large area.* Furthermore, there does not seem much justification for clinging to the elaborate classification of Dupuytren, who divided burns into six groups according to the depth of the lesion, for from a practical standpoint the surgeon knows how difficult it is to estimate the depth of a burn at the time of its occurrence. As burns and scalds differ only in causation and appearance, it will be understood that what applies to one is equally true of the other, and therefore, to all intents and purposes, the terms may be used interchangeably.

Definition.—*A burn is the lesion resulting from the application of concentrated dry heat; a scald, from the application of hot or boiling liquids or steam.* Corrosive fluids cause lesions very similar in many respects to those produced by dry or moist heat.

Classification.—Burns and scalds may be divided into three groups:

(*a*) *Burns of the First Degree.*—These may have hyperæmia and swelling for their chief characteristics. The skin becomes more or less reddened from capillary dilatation, followed by a serous exudate, which is ordinarily slight in amount. These phenomena may last for a few hours and entirely disappear. Occasionally, in persons with a delicate skin, desquamation occurs.

(*b*) *Burns of the Second Degree.*—To the hyperæmia and swelling are added vesication. The blebs vary in size and contain serum clear or light in color, and lie between the horny layer and the rete Malpighii. The time of their appearance varies from a few minutes to some hours. The swelling is greater than in burns of the first degree. The pain is also more marked, especially when the vesicles are opened and their covering removed.

(*c*) *Burns of the Third Degree.*—These include all lesions involving the entire thickness of the skin, with or without the underlying tissues. They vary, therefore, from partial destruction of the skin to complete charring of all tissues. An eschar is formed which may be dry or moist according to the individual case, and possessing varying shades of color from gray to black.

The skin surrounding the eschar is often more or less blistered, and sometimes is puckered from the drying process to which it has been subjected, and when this occurs the skin so contracted may be considered dead. The eschar begins to separate after four or five days, the process lasting from two to three weeks or even more in certain cases. Suppuration then follows, and when the defect is extensive cicatrization occurs only after weeks and months. These are cases in which the cicatrices play such an important rôle afterward, and claim the surgeon's attention either from deformities or functional disturbances occasioned by them.

General Considerations.—These injuries, where at all extensive, even though superficial, are peculiarly fatal, and have always been justly dreaded by the surgeon. The young and the old, delicate women and drunkards, are more prone to die than healthy adults. Few live when more than one-quarter of the body surface has been burned. Burns involving the *thorax or abdomen* are particularly fatal, owing to the shock and to sequelæ to be mentioned later. In cases dying within a few hours after injury no characteristic post-mortem appearances have been discoverable, so that numerous theories have been advanced to explain the lethal action of burns. We may mention only a few:

(*a*) *Destruction of Red Blood-corpuscles.*—These being essential to respiration and metabolic activity, these processes are hindered by their diminution, or else, having given up their hæmoglobin, this latter may destroy the white blood-corpuscles and produce an excess of fibrin-ferment, with subsequent coagulation of the blood in the vessels. This theory is in accord with the post-mortem findings in certain cases where an excess of hæmoglobin was found in the kidneys, these organs being hyperæmic and studded with necrotic foci. The more or less complete anuria so often observed in these cases can thus be explained by the lesions in the kidneys.

(*b*) *Over-heating of the blood*, with subsequent cardiac paralysis.

(*c*) *Excessive irritation* of the nervous system, with resulting reflex diminution of vascular tone.

(*d*) *Thrombi and emboli* from the blood-plaques, which, added to the increased adhesiveness of the blood-corpuscles, cause stoppage of the circulation.

(*e*) *Ptomaïne-poisoning*, the ptomaïnes being formed from the products of decomposition which have escaped destruction by the burn.

(*f*) *Noxious chemical substances* formed by the action of heat upon substances within the skin and then absorbed. It has been alleged that hydrocyanic acid is produced in this way, and the resemblance between the symptoms of fatal burns and poisoning by this acid have been adduced in support of the theory. It is much easier to explain the cause of death when this follows after three or four days, but, as this properly belongs to the sequelæ of burns, it will be considered elsewhere.

Symptoms.—These vary with the situation, extent, and the time following the receipt of the burn, and with the age, bodily vigor, and temperament of the individual. Given a case of extensive superficial burn involving a third or more of the body-surface, we shall find symptoms of *shock* the most prominent feature. Usually there is great pain, although in very bad cases this may be absent. The patient complains of great thirst and is more or less completely prostrated. The skin-surface is cold and clammy, the face pale, the temperature subnormal; the mouth and tongue are dry; the pulse is small and thready; the respiration shallow and panting; the mind may be clear, but commonly delirium supervenes, followed by stupor and coma. The rigors and cramps frequently seen in adults are increased to convulsions in children. Should the patient survive the following twenty-four to forty-eight hours, the phenomena of shock are succeeded by those of *reaction and inflammation*. In this stage the temperature rises, the pulse becomes

fuller and more bounding, the respiration more regular, but hurried—symptoms which are due to the pain and reflex irritation, and also to the absorption of decomposition products. It is in this stage that the more *dangerous complications* arise which so commonly cause a fatal issue. These will vary with the situation and extent of the burn. Chief among these may be enumerated the following: pleurisy, pneumonia, pericarditis, meningitis, cerebritis, peritonitis, duodenitis, and intussusception. Their importance justifies a brief consideration of some of them individually.

(*a*) *Pleurisy, Pneumonia, and Pericarditis.*—These may be considered together, as they are very commonly associated. They may be explained by the internal congestion or the septic products resulting from the burn. They appear usually about the fourth or fifth day, sometimes earlier and frequently later. The symptoms and treatment are similar to those in other adynamic forms of these diseases.

(*b*) *Meningitis and Cerebritis are not Uncommon.*—They occur most frequently in cases of burn in children, and ordinarily appear soon after the accident. The usual treatment for these diseases is to be employed.

(*c*) *Peritonitis and Intestinal Inflammation.*—These, too, follow a fairly regular course, and are to be treated symptomatically. Of the abdominal complications, duodenal ulceration is one of comparatively frequent occurrence and quite difficult to explain. According to some, the ulceration is due to destruction of the epithelium by formate of ammonium and the further injury of the mucosa by the intestinal juices; according to others, to the mingling of certain decomposition products with the bile, the mixture exciting inflammation and ulceration in the duodenum. However this may be, this complication often causes death from hemorrhage or perforative peritonitis. The symptoms are often most obscure, as pain, tenderness, diarrhœa, even vomiting and hemorrhage, may be absent, and yet perforation occur. The condition is not always fatal, however, as cicatrized ulcers are frequently found in persons who have died from other complications. Opiates form the basis of treatment.

Acute nephritis is another justly-dreaded sequel, the pathology of which has been previously alluded to. It is, in our experience, usually fatal, and for its relief a hot bath or digitalis poultice to the lumbo-dorsal region produces the best results.

The *third stage* usually begins after the second week, and is characterized by *suppuration and septic phenomena*. This stage acquires significance in proportion to the extent of the surface injured and to the inefficiency of the treatment employed, as, for instance, where septic pus is allowed to remain in contact with a granulating surface, which it quickly erodes and deepens. Should the patient survive the many complications which belong rather to this than to the preceding stage, he may finally succumb from pyæmia, amyloid changes, and resulting exhaustion. Among the important complications of this stage may be found—

(*a*) *Tetanus.*—This may occur in the preceding stages, but most often appears at this time. (*Vide* article on Tetanus.)

(*b*) *Arthritis* occurs where the burn has extended to the region of the capsule, through which, by extension of the sloughing, the joint becomes invaded and subsequently inflamed. That this inflammation does not always of necessity follow is well illustrated by a case now under the writer's care, in which, following a burn from a sky-rocket, the capsule of the metacarpo-phalangeal articulation of the left index finger was opened some weeks after the injury through ulcerative action. The joint was thoroughly washed out and the capsule stitched. Union was immediate, and perfect joint-action followed, and has so remained. Ordinarily, however, the loss of the joint may be expected to ultimately occur. Here, as elsewhere, an antiseptic regimen helps in preventing ulcerative action or mitigates it when fully established. In other respects the treatment is that of joints suppurating from other causes.

(*c*) *Hemorrhage from ulceration* extending into some vessel sufficiently large now and then causes serious and fatal results. When a burn occurs over important vessels the possibility of hemorrhage should always be borne in mind, and measures taken to prevent it from becoming excessive. For instance, when upon an extremity the patient should be shown where and how to compress the vessel until aid comes. Other expedients will suggest themselves in individual cases.

(*d*) *Cicatrices and their diseases.*

Cicatrices *are the most common sequelæ of the third stage.* They not only produce frightful deformity, but they may also impair the function of the afflicted part, so that extensive operations are often necessitated for their removal. This portion of the subject will be treated elsewhere in this work, so that we shall content ourselves here with a word as to their prevention. *Rigid asepsis* from the beginning should be aimed at. Unfortunately, only too frequently this must of necessity be imperfect or wellnigh impossible to attain, but this should not deter us from doing our best along these lines. *Early skin-grafting by Thiersch's method* should be resorted to. This measure, when done in a timely and proper way, is a most efficient one in preventing cicatricial contraction. Where and when feasible the part should be systematically moved, the natural motions being imitated so far as possible. Proper posture during sleep is a most important, but usually neglected, prophylactic measure.

Cicatrices may undergo various changes of a pathological nature. Among these is *ulceration.* This is not infrequent in scars from burns occurring in tuberculous, syphilitic, or even badly-nourished individuals. It may occur years after the formation of the cicatrix. As such cicatrices usually depend upon some depraved constitutional state, the indication is to build up the general health with tonics, nourishing food, and an existence as hygenic as possible. Locally they may be treated with solutions of nitrate of silver, 5 grains and upward to the ounce. Alum (one teaspoonful to a goblet of water), alcohol, port wine, and other astringents may be used with advantage.

Carcinoma, especially *epithelioma*, is comparatively frequent in scars following extensive burns. The writer has had occasion to amputate the lower extremity three times for such cause, and has seen a few cases in the practice of other surgeons.

The TREATMENT is removal of the affected area or, if an extremity, amputation at a suitable point.

Painful scars occur not infrequently, and are usually due to pressure upon some nerve by the contraction of the cicatrix. The pain may be very great. The therapeutic indication is to free the nerve, which may be done subcutaneously or by the open method. Often, however, the cause does not depend upon the involvement of a nerve, and must be treated upon general principles—by tonics and antineuralgic agents. Some cases cannot be relieved by any known expedient.

PROGNOSIS.—In estimating the outcome of a case of burn certain conditions deserve consideration:

(*a*) *Superficial Extent of the Burn.*—As has been previously said, when more than one-third of the entire body-surface has become involved death almost invariably occurs, and within a few hours.

(*b*) *Location of the Burn.*—When covering, in large part, the thorax or abdomen, burns are particularly prone to be followed by pulmonary or visceral complications, which only too often are fatal.

(*c*) *Children and Aged Persons bear the Shock of Burns badly.*—When children survive the stage of collapse, in our experience they bear the complications of the second and third stages about as well as adults.

(*d*) *Sex.*—Women, with their more delicate organization, suffer more shock proportionately than males.

Of the two, burns are more fatal than scalds in a given number of cases.

The PROGNOSIS regarding the local condition depends rather upon the depth of the burn, the kind of tissues involved, and the situation; thus, a burn causing entire destruction of the skin in the antero-lateral region of the neck, about the axilla or groin, or about joints generally produces more functional disturbance and deformity than one of equal severity upon the back or abdomen.

TREATMENT.—This is both *constitutional and local.*

Constitutional treatment in cases of severe burn, with symptoms of shock and collapse, resolves itself into judicious *stimulation*, *alleviation of pain*, and later the use of tonics and restoratives, together with improved hygiene.

Diffusible stimulants, such as alcohol and ether, may be given hypodermically, by rectum, or by mouth where the patient can swallow.

External warmth, particularly the hot (100°–104° Fahr.) bath, aids these stimulants.

Strychnia and digitalis, in appropriate doses (gr. $\frac{1}{30}$ of the former and 15 minims of the latter), to be repeated in two or three hours if necessary, may be advantageously used. Where the collapse is less marked and the pain excruciating it is good practice to immediately anæsthetize the patient, and then administer morphia in doses of from $\frac{1}{4}$ to $\frac{1}{2}$ grain subcutaneously. The morphia can thus be given in smaller doses and renders more efficient service than when its effects are offset by the pain. In some cases auto-transfusion and the subcutaneous injection of normal (0.6 per cent.) salt solution does great service.

LOCAL TREATMENT.—The kind and amount of treatment varies with the kind and degree of burn. The burns caused by corrosive chemicals may be in part neutralized by agents having an opposite chemical reaction or a mechanical effect. This, however, is only true when treatment can be instituted immediately or very soon after the receipt of injury.

Burns of the first degree require little or no treatment. Cooling applications, such as cool water, lead-water, starch-water, a saturated solution of sodium bicarbonate, and the like, form the most soothing applications. Powders, in the form of starch, dermatol, zinc oxide, flour, fuller's earth, and many others may be used, but ordinarily are not so grateful as lotions. Flexible collodion makes an admirable dressing, and is especially useful about the more mobile parts of the body, such as the neck, face, etc.

A domestic remedy of great efficiency in burns of even the second degree is molasses, which is best put on by soaking bits of blotting-paper about $\frac{1}{2}$ an inch by 2 inches in it before laying them evenly upon the entire surface. They must overlap each other, and when sufficiently dry an excellent covering is obtained for the part. Any excess of molasses at the edges may be wiped away and dry powder dusted upon them. Thus applied, molasses excludes the air, is soothing, and prevents decomposition, sugar being an excellent antiseptic.

Burns of the second degree may be effectually treated by the means first mentioned. In addition, the blebs frequently require attention. As a rule, they may be left for a few days (three or four) without treatment, as the raised epidermis and serum protect the underlying sensitive surface. When, however, blebs form from the action of corrosive fluids, the serum will be found of an irritating character and should be evacuated early. How this is to be done has been already explained in Chapter XVII. under the Management of Blisters.

For *burns of the third degree*, where they are at all extensive, no single procedure compares in value with the *hot bath* (100° Fahr.). It may be continued for days, and even weeks or months. It gives instant relief from pain by protecting the burned surface from the air, and for a similar reason it tends to prevent decomposition. When pus is formed it is washed away immediately, and thus a fairly aseptic condition of the burned surface is maintained. Above all, in the early stage it vigorously combats the collapse which is so often present.

For lesions of the third degree, but comparatively local in extent, the first indication is to carefully disinfect them with solutions of bichloride 1 : 2000 or carbolic acid 1 : 40, and to cut away all tissue actually dead. To do this effectually an anæsthetic is usually required.

Indeed, the anæsthetic should be given before the removal of the clothing—which, in passing, it may be said, should be removed with the utmost care, in order that the epithelial covering may be preserved as far as possible. In the majority of cases the use of some antiseptic powder is preferable to ointments as a dressing. Powders are more apt to remain antiseptic, and their power to prevent suppuration is certainly greater. An excellent powder for this purpose is one containing iodoform 1 part and boric acid 7 parts. It should be sterilized before using by steaming for fifteen to twenty minutes. It can be used generously, without fear of iodoform-poisoning, except, possibly, in the more extensive burns in young children, where the hot bath is usually indicated. Zinc oxide, bismuth, and other similar powders have been used and praised.

If *ointments* are used, a good formula is one containing equal parts of the ointment of oxide of zinc and of naphthaline, to which may be added 5 per cent. of iodoform.

Unguentin, prepared by the Norwich Pharmacal Company, is also a soothing and antiseptic dressing. Carron oil, consisting of equal parts of lime-water and olive oil, was formerly a favorite dressing, but is now supplanted by other and better preparations.

Whether powder or ointment be used, over all a thick layer of antiseptic gauze and cotton should be applied and bound firmly to the part. The dressing should not be disturbed until loosened by the discharges. In the less extensive burns oftentimes a single dressing will suffice, a dry aseptic scab having been formed, under which healing goes on without incident. The prevention of scars has already been alluded to in a previous paragraph.

Burns from Lightning.—These vary from mere reddening of the skin to the most severe forms. Coexisting with these are usually found pathological conditions of even more importance which scarcely come within the scope of this chapter, and the subject may be dismissed with the statement that, so far as the burns are concerned, what has already been said upon the subject in general applies equally to similar lesions due to lightning.

Frost-bites.

Frost-bites result from the application of *cold of an intense degree for a time sufficiently long to arrest the circulation.* They may be *divided, like burns, into three degrees*, and have a striking similarity to them. The first degree is characterized by superficial *erythema;* the second, by the formation of *vesicles;* and the third, by *eschars.*

As a rule, the parts most distant from the heart suffer most—viz. parts of the hands and feet, the nose and ears. (It is interesting in this connection to note the immunity from freezing possessed by certain exposed parts, such as the eyelids and eyeballs.)

Pathology.—When a part is exposed to cold, contraction of the blood-vessels, followed by retarded circulation, is the first phenomenon to be noted. Depending upon the intensity of the cold and the duration of exposure, this contraction may proceed to complete obliteration, when the exposed surface becomes white in color. (This can be easily demonstrated experimentally with the ether spray when used as a local anæsthetic.) If, now, warmth be applied, dilatation of the vessels, with severe pain, stasis, thrombosis, and even gangrene, follows.

Among other changes that have been noted are rupture of the vasa vasorum and interstitial hemorrhage, ascending neuritis and degeneration of the nerve-tubules, leading frequently to muscular atrophy, trophic ulcers, etc.

Symptoms.—These are both *constitutional* and *local*, varying with the degree and duration of exposure to cold.

Constitutional Symptoms.—In extreme cases these are manifested by a subnormal temperature, difficult respiration, slow pulse, dilated pupils, which react sluggishly, incoördination, apathy, and a tendency to sleep, which is so irresistible that the individual will consciously lie down to certain death.

Local Symptoms.—The *first degree* is characterized by a deep-red color and more or less evident swelling in the affected tissues. The retarded circulation is shown by the slowness with which the color returns after its dissipation by pressure. The part may become more or less painful as warmth is applied; usually only itching is present. This degree of frost-bite, frequently repeated, leads to the well-known condition of *chilblains.*

In *frost-bite of the second degree* the color becomes of a deeper red or bluish tint, and the part is more or less covered with blebs. These may break, leaving ulcers which are extremely slow in healing. Indeed, frost-bites of the second degree are usually more intractable than burns of the same degree—*i. e.* the vitality of the tissues is more depressed.

In the *third degree* the part becomes dark blue in color or marble-like, is anæsthetic, and is covered with blebs. Soon gangrene, local or general, supervenes, followed frequently by sepsis, producing general disturbance.

Treatment.—This will vary according to the extent of surface involved and the degree of the freezing.

The treatment when a large portion of the entire body is frozen consists in the *gradual* application of *warmth.* This is done by putting the patient in a cold room, rubbing him with a sponge soaked in cold water,

later putting him in a cold bath (60° F.), the temperature of which is gradually raised to 90° in the succeeding three or four hours.

Stimulants may be given subcutaneously, or, in cold water, by mouth where the individual can swallow. (Large, hot enemata should *not* be used, as thrombosis and gangrene of the bowel may be easily induced.) Vertical suspension of the part (the extremities, for instance) should be resorted to early. When pain is severe it may be mitigated by the application of cold in some form, as the snow-poultice, ice-bags, or cold wet cloths. *Artificial respiration* should be practised, and continued for a long time, even though its effects are not at first apparent.

Local Treatment.—The treatment of a part is conducted along lines similar to those just considered as applicable to freezing of the entire body. The restoration to a normal temperature must be gradual; therefore snow or ice should be first used and followed by warmer applications. Dry rubbing of the part is also useful. When *ulceration* has occurred, it may be treated as in the case of burns with any of the various antiseptic powders or ointments previously mentioned. Where the frozen surface is extensive, the continuous bath may be used with great advantage, and for the same reasons that indicated its use in burns. Its temperature will of course be regulated by circumstances. We have in mind here the bath as used after reaction has been finally established. When the part becomes *gangrenous* we should redouble our antiseptic precautions, and when a line of demarcation has formed between the living and dead tissue, remove the latter. In the case of an extremity this means amputation or disarticulation. Where suppurative cellulitis occurs it must be met promptly with free incisions, disinfection, and thorough drainage in the usual way.

CHAPTER XXIX.

THE MUSCLES, TENDONS, AND TENDON-SHEATHS, BURSÆ, AND FASCIÆ.

By Herbert L. Burrell, M. D.

Malformations.

Congenital muscular deformities are met with occasionally. They are always due to either the absence of certain muscles or to the presence of supernumerary muscles. The absence of the pectoral muscles is recorded.

Webbed fingers, or syndactylism, is a congenital fusion, more or less perfect, of two or more digits. It is not very rare; it often occurs in more than one member of a family, and frequently recurs in succeeding generations. It is due to the grooves in the hand of the fœtus failing to become clefts. The "webbing" may involve two or more fingers in one or both hands, the union being partial or complete. The indi-

Fig. 195.

Webbed and supernumerary fingers.

vidual fingers in form are frequently perfectly normal. They may be joined in three ways: first, by a narrow or wide web of skin and connective tissue; second, they may be in close apposition; and third, the bones of two fingers may be fused together either partially or throughout their length. The usefulness of the hand is often but little impaired. Supernumerary fingers not infrequently occur in conjunction with syndactylism (Fig. 195).

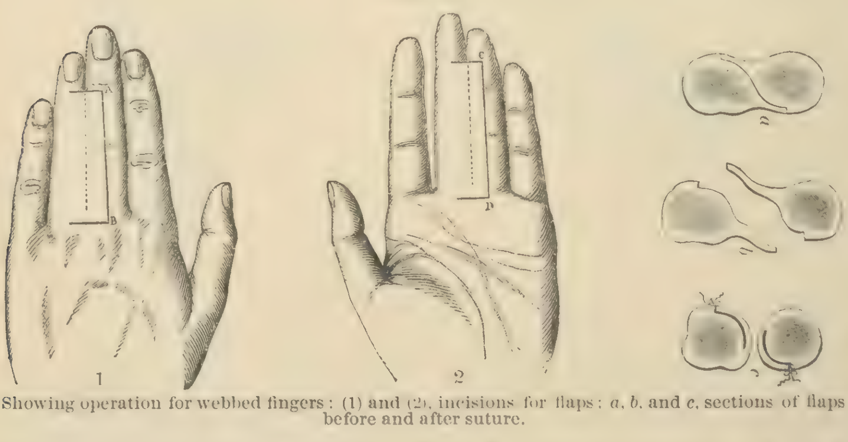
Treatment.—If the bones of any two fingers are united throughout their length, it is unadvisable to attempt to separate them. The old operation for this deformity consisted in merely dividing the web

Fig. 196.

Congenital defects: "webbing" of lower extremity. In lumbar region a pendulous lipoma resembling a rudimentary tail (Wolff).

from top to bottom, and in trying to prevent the fingers from reuniting. This method has been practically abandoned, because it is impossible to prevent a portion of the web from re-forming, and, on account of

Fig. 197.



Showing operation for webbed fingers: (1) and (2), incisions for flaps: *a*, *b*, and *c*, sections of flaps before and after suture.

cicatricial contraction, separation of the fingers is incomplete. A good method of treatment is to first make a small permanent opening between the bases of the fingers. This opening may be established by keeping

in it an elastic ligature or a silver wire, with the ends attached at the wrist until the edges are united. After these edges are well covered with epithelium the remainder of the web is simply cut through.

The best *operation,* and the one generally used, is illustrated in Fig. 197. Two flaps are taken, one from the palmar surface of the first finger, and the second from the dorsal surface of the next, by incisions made along the median line of the fingers (*a*). By so doing two flaps are obtained, each of which is of the length of the finger and in width equal to a quarter of the whole circumference of one finger with the added width of the web (*b*). These flaps are freed so that the palmar flap of the second finger remains attached to the first finger, while the dorsal one from the first finger remains attached to the second finger. The flaps are then brought around each individual finger and sutured into position (*c*). Care must be taken to adjust the flaps and sutures accurately at the base of the fingers, and the fingers must be kept well apart by the dressing; otherwise a partial failure may occur. In case the bones are only united for a slight distance they may be cut or sawed apart. Other methods of treatment are sometimes described, but they do not differ essentially from those given here.

Webbed toes are less frequently seen than webbed fingers. As the deformity interferes but little with the usefulness of the foot, and as the parts are concealed from sight, operations are unnecessary. Should an operation be desirable, however, it would be done in the same manner as for webbed fingers.

Webbed knee is a very rare condition. The femur and tibia are not fused, but the knee-joints are flexed by a web of skin and connective tissue in the popliteal space. In one instance, where both knees were in this condition, a typical plastic operation corrected the deformity, but it was necessary to divide the outer and inner hamstrings.

SURGICAL INJURIES OF MUSCLES AND APONEUROSES.

Aponeuroses are either thin, flattened, or ribbon-shaped structures serving the same purpose as tendons by attaching the broad flat muscles to the bones, or they are membranous, composed of interlacing fibres surrounding the muscles and preventing their displacement and being continuous with the muscle-fibres. They are rarely the seat of active disease or injury, but they are important in forming a barrier to the extension of inflammation and suppuration from one layer of tissue to another. A thorough knowledge of their arrangement is of great value to the surgeon, for they frequently impede the progress of inflammatory products toward the surface, and by so doing conceal and favor invasion of the deep structures. Punctured wounds and ruptures of the aponeuroses are the only ones which need surgical attention. The former may occur in any punctured wound of the skin, and does not require special treatment. The latter may give rise to muscular displacement or hernia, and the treatment is described below.

Muscular hernia is the protrusion of a limited portion of the muscular substance through its ruptured fascia or aponeurosis. This occurs only during contraction, forming an elastic tumor which disappears during relaxation. It results in impairment of muscular powers.

The DIAGNOSIS is easily made and the wounded edges of the tear in the aponeurosis can be readily felt.

TREATMENT.—In recent cases rest and pressure generally result in a cure. If necessary, the edges of the opening in the fascia should be

freshened and brought together by sutures. If the discomfort caused by a muscular hernia is only slight, an improvised pad or truss may relieve the patient.

Injuries of Muscles.

Muscles from their situation are frequently exposed to violence, yet they are not commonly injured, nor are they frequently the seat of surgical disease. They are liable to contusions, strains, ruptures, dislocations, and wounds.

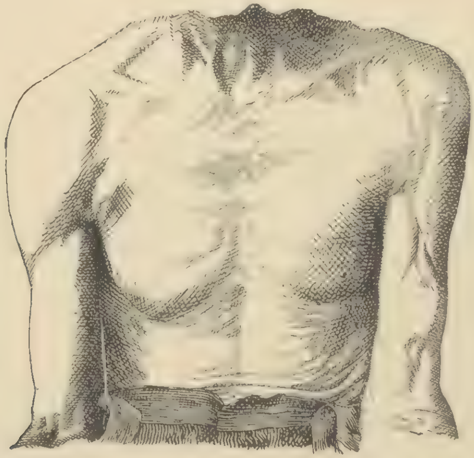
Contusions may be slight or severe. A slight contusion, if it occurs in a healthy muscle, may be quickly recovered from. Severe contusions are accompanied by swelling and discoloration of the overlying skin. Inflammation, suppuration, and atrophy may ensue, the latter probably being the result of accompanying nerve-injury.

Hæmatoma of the sterno-mastoid muscle is a condition which is sometimes seen in apparently healthy children at birth or shortly after. It is usually a localized swelling in the body of the muscle, but the whole length of the muscle may be involved. It is thought to be due to pressure or to partial rupture of the muscles from traction during birth. It is always unilateral, and it disappears spontaneously in from two to six months.

Gaudier has reported two cases in infants where during vaccination a sudden muscular action, due to turning the head aside, ruptured some of the muscular fibres of the sterno-cleido muscle, and there resulted a hæmatoma. These cases are unique, in that hæmatoma has always been considered a condition arising through pressure or traction in delivery.

A strain is a stretching of a muscle, with probably always a small amount of rupture of muscle-fibre. Strains are often followed, espe-

Fig. 198.



Ruptured long head of left biceps muscle (case of Dr. George H. Monks).

cially when they occur late in life, by troublesome pain resembling rheumatism. Strains occur most frequently in the muscles of the back,

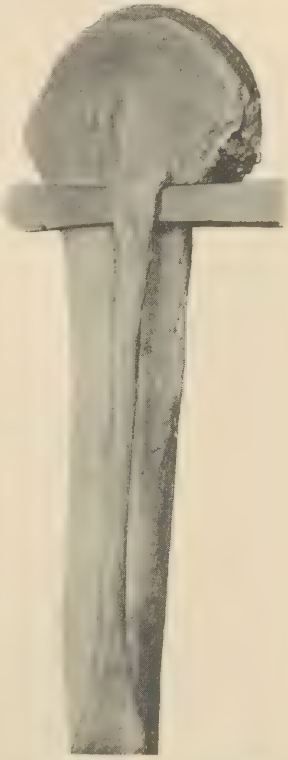
hips, shoulders, arms, and legs. They occur often as a result of violent muscular efforts.

TREATMENT.—During the acute stage of either a contusion or a strain, rest to the affected parts is imperative. Hot fomentations or evaporating lotions are adjuvants to be used. As soon as the pain and tenderness diminish, massage, passive motion, liniments, and electricity may be applied.

Subcutaneous rupture of healthy muscles and tendons is of comparatively common occurrence; for example, in most cases of strain some rupture of the muscle ensues.

Complete rupture of a muscle is rare. Rupture generally takes place in the tendon near the union with the muscle or at its insertion on the bone. The power of resistance of a healthy muscle is very great, and it is said that ruptures occur only as the result of some involuntary action and when the muscle is taken unawares. Rupture of either a muscle or tendon is accompanied by sudden, violent pain and loss of power. A distinct snap is almost always heard. There is usually, unless the affected muscle or tendon lies deeply, a marked depression between the severed ends. This depression, which is easily felt at first, is often masked by the accompanying swelling which quickly comes on, and is due to the extravasation of blood in the surrounding parts. The tendons of the biceps, the triceps, the deltoid, and the pectoralis major have been torn apart by violent exercise, in lifting or clutching at some object in falling; the sterno-mastoid from violent vomiting or excessive traction in childbirth; the pronator radii teres and plantaris in lawn-tennis; the rectus abdominis and the internal and external oblique muscles in tetanus and from falling across iron bars; the tendo Achilles and gastrocnemius on alighting suddenly from a height; the quadriceps extensor tendon, the ligamentum patellæ, the biceps femoris, and rectus femoris by falling backward or forward on the ice; adductor longus in horseback riding; semimembranosus in lifting; and the muscles of the perineum and sphincter ani in parturition. Following long and exhaustive illnesses, such as occur in typhoid, typhus, and scarlet fevers, the muscles and tendons lose their power of resistance and often rupture from the very slightest muscular force.

FIG. 199.



Long head of biceps muscle which had ruptured, and had formed a new attachment in the bicipital groove.

The flexor and extensor tendons of the hand are ruptured at their insertions. This accident occurs frequently to ball-players. In violin-playing the extensor tendon of the middle finger of the left hand has been torn away.

TREATMENT.—In the simple forms of rupture the treatment consists of *absolute rest* in a position which gives the greatest degree of relaxation to the injured part and approximates as closely as possible the ruptured ends of the muscle and tendon. *Compression* by bandages and splints is used when necessary. The application of ice or anodyne lotions hastens the absorption of the effusion and promotes early repair. When the function of the ruptured muscle or tendon is one of considerable importance, or it is obvious that the ruptured ends will not unite, it is necessary to *suture* the same by open incision under antiseptic precautions. The flexor and extensor tendons of the hand, the quadriceps and patellar tendons, and the tendo Achilles are the principal ones which require operation. Catgut or silk is used for the suture and the wound is closed without drainage, the limb being placed in the most favorable position for relaxation of the affected part. Contractures sometimes develop subsequent to muscular ruptures. This is due to the action of antagonistic muscles, as in congenital torticollis from rupture of the sterno-mastoid, or to contraction of the cicatricial tissue.

Dislocations of muscles and tendons are caused by the laceration of their fascial and synovial sheaths. They are not frequently seen, and those tendons most liable to dislocate are the long head of the biceps from the bicipital groove, the peroneus longus, the peroneus brevis, the tibialis posticus, and the plantaris in severe sprains of the ankle-joint; the sartorius and quadriceps in severe sprains of the knee; and the extensor tendons on the back of the wrist, as well as the flexor carpi ulnaris in sprains of the wrist. The latissimus dorsi muscle may become displaced where it passes over the lower angle of the scapula, and is recognized by the prominence of that portion of the bone. Dislocation of a muscle or tendon is recognized by acute pain, by a certain amount of loss of function in the part, and by the jumping of the tendon from its anatomical position on contraction.

TREATMENT.—The tendon or muscle may be readily reduced by manipulation of the limb and by pressure, in the majority of recent injuries. The difficulty is to keep the tendon in position, and it is doubtful if a ruptured tendon-sheath ever unites. After replacing a tendon it should be held in its position by a dressing which maintains pressure at the point of dislocation while the injured part is placed in a relaxed position; for example, in the peronei tendons this would be with the foot extended and abducted. If, after treatment in the above manner for several weeks, the dislocation persistently recurs, an *operation* for its cure is justifiable. Under full antiseptic precautions an incision is made, the lacerated edges of the sheath should be freshened and sutured together over the tendon, or, if the dislocation is out of a groove in the bone, the periosteum may be raised, the groove deepened, and the periosteum, with the sheath, sutured over the tendon.

Wounds and sections of muscles and tendons may be classified, in the same manner as wounds of other tissues, into incised, contused, lacerated, punctured, and gunshot.

TREATMENT.—This is the same as is applicable to wounds of the same character in other tissues. The essentials are arrest of hemorrhage, thorough cleansing, the removal of all extraneous matter, and accurate approximation of the ends of the cut muscular fibres as far as it is pos-

sible to attain by suturing with catgut or silk. If there has not been extensive loss of tissue, true muscular regeneration may occur and loss of function may not ensue. Absolute rest until union has taken place is essential. If kept free from sepsis, the gravity of these wounds is usually slight. Complete division of tendons is much more common than of muscles, and even at the expense of materially lengthening the original wound the cut ends must be found and carefully sutured. Considerable difficulty is often experienced in securing the divided tendons of the hand and forearm, and, when several have been severed, in adjusting the proper ends one to the other. If the wound has been allowed to heal without the tendon having been sutured, it is necessary to reopen the wound, find, freshen, and suture the ends, in order to restore power to the divided structure. In gunshot wounds there is usually only slight destruction of tissue: the muscles and tendons are partially cut through, apparently being separated and pushed to one side. These wounds should not be sutured, but cleaned, packed lightly with iodoform gauze, and allowed to granulate.

Regeneration of Muscles and Tendons (*vide* Chapter XXII.).—Regeneration of muscular tissue takes place only to a limited extent after loss of substance.

Normal increase in size of muscles occurs chiefly through the increase in size of the individual muscle-fibres. There is first seen an increase in size and number of the muscular nuclei by division. These new cells or sarcoblasts are spindle-shaped, gradually lengthening out, and showing striations. Eventually, each one forms a muscle-fibre. In slight wounds and injuries the cicatrix may be entirely muscular, but when the loss of tissue is extensive the defect is largely filled by connective tissue. After section of a tendon, regeneration occurs in one of two ways: If the space in the sheath between the divided ends becomes filled with blood, a callus of granulation-tissue is formed around the tendon and sheath which gradually encroaches and absorbs the blood-clot. This in time becomes practically normal tendon-tissue. The process is accomplished by proliferation of the cells of the tendon itself and of the tendon-sheath. If the blood-clot is absent in the sheath, its walls come together and unite, in this way uniting the ends of the tendon.

Diseases of Muscles.

Myalgia is often known as *muscular rheumatism* or *neuralgia*, neither term being strictly correct. It is a painful affection of the voluntary muscles, and oftentimes dates from some strain or blow. It is characterized by sudden pain and is intensified by strain or exposure. It occurs most frequently in the muscles of the back and in the neck. It is occasionally found to depend upon some specific cause, such as syphilis, tuberculosis, lead-poisoning, or malignant disease.

Treatment.—Subcutaneous injections of one-sixtieth of a grain of *atropia* into the body of the muscle are said to give prompt relief. Other remedies are massage, electricity, hot baths, dry heat, and the administration of salicylic acid and iodide of potassium.

Functional Disorders of Muscles.—Temporary loss of muscular power, with or without spasmodic contraction, is a condition occasionally seen. It comes in muscles which have been overworked, subjected to any unusual strain or position, or exposed to cold. A common example is *writer's cramp*, in which the muscles of the hand are affected only when holding a pen. It begins gradually, but very soon the hand is com-

pletely disabled. A general nervous condition, with fatigue, predisposes to its development. General systemic treatment, as well as complete rest and local massage with electricity, comprises the treatment. Various devices for its relief and prevention have been contrived, the bracelet of Nussbaum, which allows the patient to continue his writing, being the most useful one. Another frequent form of cramp is the excessively painful tonic spasm which comes on in the calves of the leg after over-exertion, as in mountain-climbing or after remaining long in one position. It sometimes attacks one when quiet in bed, probably caused by the foot being held in a particular position. The death of skilful swimmers may be due to attacks of muscular cramps of this description.

Myositis and Inflammation of Muscles.—Hyperæmia in muscles may be due to traumatism, inflammation, to extension from contiguous inflammation, or to an infection from the presence of micro-organisms. In muscle as well as in other tissue inflammation results in effusion, suppuration, ulceration, and necrosis. The limited amount of inflammation of muscle which follows a simple contusion is characterized by an exudate of serum and by cellular infiltration around and between the muscle-fibres. If the trauma is sufficient to do permanent injury to the muscle-tissue, and there is no infection to produce suppuration, cloudy swelling and coagulation-necrosis follow. The defects caused by this necrosis in the muscle-tissue are to a certain extent replaced by the proliferation of muscle-cells, as has been described under Regeneration of Muscles. If this necrosis is extensive, there is a considerable formation of fine connective tissue in the muscle-substance. These simple forms of hyperæmia are known as *myositis serosa* and *myositis fibrosa*.

Myositis purulenta is the suppurative and gangrenous form of inflammation, which is always due to bacterial infection. It may be either acute or chronic, occurring in the form of abscesses or as diffuse suppuration. It occurs in the course of compound fractures, in general septic infections, and in endocarditis, erysipelas, typhoid fever, and tuberculosis.

Myositis ossificans is a peculiar form of inflammation in which plates of bone are developed in the substance of the muscles. It may occur in connection with the formation of callus in the bone after fracture and as a result of continued or frequently repeated irritation or traumatism.

Rider's bone is a small plate of bone in the adductor longus muscle of the thigh, forming as the result of knee-pressure against the saddle. *Drill bone* is a similar condition in the deltoid muscle, and is occasionally seen in soldiers.

Treatment.—Complete excision of the deposit is called for if the symptoms produced are annoying.

There is a more general form of muscular ossification known as *progressive myositis ossificans*, in which a large number of muscles in the body gradually become the seat of extensive bone-deposits. This may come on as the result of a slight blow or even without apparent cause. In the beginning small, hard nodules are felt, which increase in size and become true bone, branching out through all the muscles, especially those of the back. If seen early in the course of the disease,

the deposits may be excised, but the severe cases are usually helpless from the inception of the disease. The etiology of this disease is obscure. It has been suggested that it is congenital and that it is due to the fœtal development of bone not ceasing.

Calcification of Muscles.—This is a condition in which there is a deposit of lime salts in the muscles. It may occur in two forms: first, as masses which are known as *concrements*, which merely lie in the body of the muscle, or, second, as a *general infiltration* into the muscle-fibres. The first form is the ultimate result of tubercular necrosis and abscess-formation. Only a part of the necrosed mass is absorbed: the remainder becomes caseous, then calcified, and is enclosed in a capsule of connective tissue. If this inspissated substance gives rise to trouble, it may be readily excised. The second form, which is more properly spoken of as calcification, is a genuine infiltration, and is exceedingly rare in muscles. It has been found in the muscles of the legs.

Degeneration of Muscles.—The muscles, like other tissues, are the seat of various forms of inflammatory degenerations. Some of these constitute definite surgical lesions, others are the sequelæ or manifestations of general disease, while still others may be the result of poisoning by arsenic, phosphorus, etc.

Cloudy Swelling and Fatty Degeneration.—In cloudy swelling or granular degeneration there is an increase in the size of the cells due to the accumulation of fine granules in the protoplasm.

The tissue macroscopically has a dull, cloudy aspect, and under the microscope the granules obscure the cell-nuclei, which become visible on the addition of acetic acid. This degenerative process may disappear and the cells return to their natural condition, or the granular material may break down and disappear. *Fatty degeneration* may exist with *cloudy swelling* or may result from it. In fatty degeneration the drops of fat are seen in the cells, being formed probably by the destruction of cell-albumen. In normal tissue the muscle-cell contains no fat, although there is a certain amount of fat among the muscle-fibres. An increase of the latter is not fatty degeneration. Fatty degeneration occurs as the result of diminished oxidation, or it may result from anæmia, from various forms of acute or chronic poisoning, from the acute infectious diseases, and from inactivity of the muscles following paralysis or ankylosis.

Waxy degeneration of the muscles is a form of coagulation-necrosis in which the muscle-fibre in places becomes disintegrated and the contractile myosin coagulates into refractive homogeneous masses. The fibres enlarge and become transparent from the presence of colloid material in the cells. The striations disappear, their position being indicated by lines of separation in the refractive masses. This degeneration may result in the destruction of individual muscle-fibres or of large areas of muscle, which are always incapable of repair. The muscle, to the naked eye, resembles the flesh of fish, having a dull, grayish color. Waxy degeneration of muscles occurs in consequence of long-continued febrile conditions; in the abdominal muscles after severe typhoid and puerperal fevers; in tetanus and after extensive bruising, crushing, or tearing.

Amyloid Degeneration of Muscles.—Amyloid disease is one of the degenerative processes which more rarely attacks muscles than the other tissues. Not infrequently it occurs in the muscles of the heart, the tongue, and the larynx as a result of inflammatory processes. It

is characterized by the deposit of a peculiar albuminous material known as *amyloid substance* between the muscle-cells rather than in them. This results in cell-atrophy and loss of function. It follows extensive syphilitic lesions, and is a sequel to long-continued suppuration, especially tubercular and other infectious bone-processes. The disease is generally regarded as incurable, and it is important that it be recognized by the surgeon. All authorities consider that extensive amyloid disease is a contraindication to operation. The writer, however, has successfully operated on a number of patients who have had amyloid disease.

Syphilis of Muscles.—Syphilis of the muscles is not rare. It may manifest itself at any time in the course of the disease, especially in the tertiary stage. It may appear localized as a gumma or as a diffuse syphilitic myositis. Gummata are found generally in the muscles of the legs, arms, and neck. The muscles of the tongue are frequently involved, and even the heart and diaphragm may be invaded. They occur as distinct rounded tumors in the body of the muscle, varying in size up to a pigeon's egg or even larger. Three have been observed in one sterno-mastoid muscle. These swellings are frequently so hard and so well defined as to lead to an operation, and excellent surgeons have erred in attempting their removal. These syphilitic growths are usually of an unstable nature, there being an extravasation of leucocytes without the formation of granulation-tissue. The leucocytes perish by fatty degeneration; suppuration and ulceration ensue; small areas may be reabsorbed. In larger gummata there may be a central zone of caseation, surrounded by granulation-tissue which becomes transformed into connective tissue and causes the common depressed cicatrix of syphilis.

The DIAGNOSIS is at times very clear, but gummata are frequently confounded with malignant growths; in fact, not infrequently the diagnosis is established by the success of the syphilitic treatment.

Syphilitic myositis may, as a rule, be differentiated from ordinary myositis by the history, by the less acute course of the symptoms, and by the peculiar swelling and induration of the affected muscles, usually spoken of as "woodeny." It is characterized by an exudation into the interstitial connective tissue and the sarcolemma.

The walls of the vessels, especially the arteries, are likely to be involved. They are thickened and the lumen reduced in size or even occluded. The muscles of the neck are a favorite seat for specific myositis. The writer has recently seen a case where almost the whole length of one sterno-cleido-mastoid muscle was infiltrated by this process, causing a prominent swelling throughout the side of the neck and simulating deep cellulitis. In this instance an incision was made into the substance of the muscle with the idea that pus might be present: it was only when a small portion of the muscle was excised and examined microscopically that the diagnosis of syphilis was made. Permanent atrophy and contracture of the muscle frequently follows this disease.

Syphilis of muscles, as a rule, runs a chronic course. In adults it occurs as a tertiary lesion, but in children, especially in infants, it may be one of the earliest manifestations of the disease. In addition to the above forms of muscular syphilis there is occasionally seen a form of *syphilitic contracture of the muscles.* It occurs chiefly in the flexors of the arm and forearm, but occasionally it is seen in the biceps. It begins insidiously with slight pains in the fleshy part of the muscle,

soon accompanied by weakness and unsteadiness of action. Later there occurs a slowly-progressing contraction of the muscle itself. Occasionally the first symptom noticed is stiffness in the elbow-joint, extension becomes limited, and the forearm remains partially flexed, and, if the arm be forcibly extended, the muscle is found to be tense or prominent and in a state of spasm. There are no other distinguishable changes in the muscle than its shortening and tension.

This condition has been frequently attributed to rheumatism, traumatism, and other causes, but in most cases a definite history of syphilis may be obtained, and the disease usually yields readily to treatment. It is due to a subacute inflammation in the muscles. A very troublesome myositis is occasionally seen in the sphincter ani of syphilitic women, which gives rise to much pain and discomfort. All forms of syphilitic disease are amenable to a vigorous course of mercury and iodide, and in cases of doubtful diagnosis it may be well to defer other treatment until this has been tried. Undoubtedly many of the so-called rheumatic pains, indurations, and contractions in muscles are due to syphilis.

Tuberculosis of Muscles.—Primary tuberculosis of muscles probably never exists, and muscular tuberculosis of any character is of very rare occurrence. As a rule, it is secondary to tubercular disease of the surrounding parts, such as bone, tendons, etc. It may occur in general miliary tuberculosis, following the absorption of tubercle bacilli from the circulation. In the former case it is seen in the adjacent muscles—for example, in hip- and other joint diseases—or may give rise to tubercular cold abscess. Tuberculosis of the tongue is occasionally seen, and may readily be confounded with syphilis or cancer.

Muscular contractures may be of two distinct varieties—the first a simple muscular *rigidity* or *spasm*, and the second a permanent *non-relaxing muscular contraction*. The former is nothing more than a spasm of the muscles set up by extrinsic causes, either traumatic or inflammatory. An example of the traumatic form occurs in fractures, and disappears when the fracture is controlled. Rigidity and spasm, which always accompany joint diseases, especially in the acute stages, are examples due to inflammation. This spasm and rigidity are the cause of the characteristic deformities in hip-, knee-, and elbow-joint diseases and of the limitations of motion found in the early stages.

There is a *rare form of permanent congenital contraction* of the muscles of the fingers and toes which may involve several digits of either the hands or feet. Generally, these contractions are in the position of flexion, but there may be hyperextension. In some of these cases there seems to be a distinct hereditary history of such deformity. Defective development of the bones may accompany muscular contraction.

TREATMENT should consist of massage and manipulation, to be followed in case of failure by forcible extension under ether and retention by splints. Finally, division of the muscle or tendon, or even amputation, may be required to relieve certain cases.

Permanent muscular contractions are acquired as the result of many causes. A mild form follows prolonged rest in a constant position. This takes place when an arm has been confined for a long time, without passive motion, on an internal angular splint. This temporary acquired contraction is not at all uncommon following the treatment of fractures involving the joint, and massage, passive motion, and, if necessary, active motion under an anæsthetic, are indicated. Severe and painful contractions of the muscles often follow the various infective inflam-

mations. Every surgeon not infrequently sees extensive and permanent contraction of the muscles of the hand and forearm following an infective cellulitis which may have come from a small wound on one finger. The inflammatory process in these cases has penetrated to the muscle itself, and has caused an atrophy of the muscular fibres and an adhesion between the muscles and tendons themselves.

TREATMENT sometimes seems almost hopeless. Massage and forcible extension, persisted in for a long time by surgeon and patient, result in some improvement; even repeated etherizations are at times necessary.

Cicatricial contractures of muscles follow *injuries*, loss of substance, or *burns*, and the deformity is due to either the injured muscle itself or to the superior strength of the antagonistic muscle. In adults contractions of the muscles are seen as late results of *hemiplegic paralysis*. They occur commonly in the flexor muscles of the arm and leg. These flexions can be partially overcome by passive or active motion, but cannot be permanently relieved by any treatment.

Muscular Atrophy.—Simple muscular atrophy is a condition frequently seen by the surgeon and under a variety of circumstances. The most familiar form is due to *rest* or some prolonged illness, and is not the result of disease in the muscle itself. Atrophy does occur as the result of imperfect assimilation. It may be brought about by interruption of the local *circulation* or by *disturbed innervation*, either from injury to the peripheral nerves or the central nervous system. There is also *senile* atrophy which is due to the constant expenditure of force, causing a waste of tissue in excess of the power of regeneration. Atrophy is a diminution in the amount of the normal tissue, without any material change in the structure of the muscle itself (Chapter I., Consequences of Disturbed Nutrition). The atrophy of disuse follows the pressure and confinement by splints after fractures and dislocations. It is greater in that part of the limb above the injury than in that below.

The atrophy which is seen as the early symptom in all forms of joint disease is not, as is generally believed, occasioned by the enforced disuse of the part. It is supposed to be due to reflex disturbances of the trophic nerve secondary to the disease in the joint. Brown-Séquard believed that it was a direct irritation of the nerves independent of the trophic centres. Atrophy following lesions of the brain and cord and in wasting diseases, as typhoid fever and phthisis, may be from either *disuse* or *malnutrition*. In conjunction with the various forms of muscular degeneration which occur, particularly in syphilis, rheumatism, typhus fever, alcoholism, and lead-poisoning, there is always a certain amount of atrophy of the muscular fibres.

Progressive muscular atrophy is a peculiar chronic affection characterized by a wasting and loss of power of individual and groups of muscles. It is progressive, commonly hereditary, and apt to begin in the muscles of the hand. Excessive muscular exertion, combined with exposure to cold and dampness, is supposed to be a predisposing cause. While its pathology is not well understood, lesions have been found in the spinal cord in a number of cases.

The TREATMENT in all forms of muscular atrophy is practically the same. It consists mainly in attempting to restore the wasted tissues as far as possible to their normal conditions. This in many instances may be accomplished by passive motion, massage and rubbing of the parts, muscle-beating, baths, and electricity. These, begun early, not only keep

the muscle well nourished, but at times seem to delay the progress of the affection.

Muscular Hypertrophy.—Hypertrophy is an increase in the size of a part with retention of its normal structure. In muscle it is due to increase in size of the individual muscular fibres, and not to the formation of new tissue, except perhaps to a very limited extent. True hypertrophy of the muscles arises from their increased use and is essentially a physiological condition.

Pseudo-muscular hypertrophy or **pseudo-hypertrophic muscular paralysis** was first described by Duchenne in 1858, and for a long time

Fig. 200.

Pseudo-muscular hypertrophy: case of Dr. E. G. Brackett, showing characteristic attitude of child.

the disease was known more commonly under his name. It should unquestionably be classed under the neuroses, but as cases come to the surgeon for treatment, and as it has always received a place in surgical literature, it deserves some notice here. It is a disease characterized by a great increase in size of certain groups of muscles, together with a diminution in their power and functional activity. At the same time there is also a diminution in the size of other muscles, together with a loss of power.

The muscles most frequently involved are the extensors of the leg, those of the calves, the glutei and lumbar muscles, the deltoids, the triceps, and the infra spinati. The muscles of the face, neck, forearm, and hand are rarely affected. In the muscles which are apparently hypertrophied, as well as those in which there is atrophy, there is a general atrophy of the muscle-fibre itself, but in those that are hypertrophied there is a great increase in the connective tissue and fat,

by which, in the later stages, the muscle-substance is largely replaced. This increase in fat and connective tissue accounts for the apparent enlargement in the muscle itself. However, in the early stages there has been noticed a marked enlargement of a few of the muscle-fibres and an increase in the nuclei of the sarcolemma. The atrophy of the fibres and the replacement by connective tissue and fat seem to be processes which go on during the progress of the disease.

The disease in many instances is probably congenital, and seems to be transmitted in a family through several generations. The disease may not be recognized until the child begins to walk, when it is noticed that it is clumsy in its movements and that it stumbles and falls easily. As the trouble advances the attitude in standing and walking becomes characteristic. The legs are wide apart, abdomen prominent, with a pronounced curve in the spine, while the gait has a peculiar waddling character. The muscles themselves feel hard, firm, and elastic.

The DIAGNOSIS is usually not difficult when one considers the apparently robust appearance with the weak condition and the attitude, gait, and size of the muscles. The disease occurs in males much more frequently than in females, and in the majority of cases appears in childhood, but it may develop exceptionally in young adults. The progress of the disease is slow but constant, the paralysis becoming general and increasing until the patient is bed-ridden, when he frequently dies of some intercurrent disease.

Traumatic Muscular Paralysis.—Persistent paralysis of one or more muscles may occur as the result of direct violence to the muscle itself or to its nerve-trunk. The former is not common, but a patient is occasionally seen who, after a violent blow on the belly of a muscle—for instance, the biceps—has considerable contraction, followed by paralysis and atrophy. The more common form of muscular paralysis is a result of injury to the nerve, and it is seen in the arm following pressure upon the circumflex and musculo-spiral nerves. Examples of this occur in *crutch paralysis* from the continued use of crutches, from pressure during sleep caused by the weight of the body or head resting on the arm, from the arm hanging over the back of a chair, following dislocations at the shoulder-joint, and after fracture from the involvement of the nerve in the callus.

Direct muscular action, as in throwing a ball, may cause the same thing. When the trouble is occasioned by the use of a crutch it usually may be recognized in time to avert serious trouble. It begins with numbness and tingling in the fingers, soon followed by muscular weakness and paralysis if the cause is not removed.

The TREATMENT is rubbing, massage, hot and cold douching, electricity, and passive motion. The recovery is usually very slow, and months may pass before the patient shows any improvement.

Dupuytren's contraction is the name given to a condition not infrequently seen, principally in men of middle age, in which there is permanent flexion of one or more fingers, usually the third and fourth. It is due to a contraction of the palmar faesia. It has no English synonym, and ever since Dupuytren first demonstrated that the deformity was due to contraction of the *palmar fascia*, and not to the flexor tendons, the disease has been identified with his name. It is a condition which is seen in men much oftener than in women, and, while it may affect either or both hands and any finger, yet the ring and little fingers are usually the ones involved, and often the two together. It is an acquired disease, and, although the etiology is still a mooted point, as widely different views of its origin are held, yet it is certain that different conditions bring about the same disease. It seems to be most frequent in people of a rheumatic or gouty diathesis, and especially where it is hereditary. The disease has been ascribed to repeated slight

traumatisms to the palm of the hand, such as occurs in the use of particular tools; again, to nervous and inflammatory causes. A few cases can be traced to syphilitic origin in which treatment begun early in the contraction has resulted in cure without operation. It seems probable that it arises as the result of a chronic inflammatory process which attacks the palmar fascia, and that various constitutional conditions may be responsible for its occurrence. Why the palmar fascia is singled out, and the reason that some of the fingers, and not all, are attacked, are not manifest.

FIG. 201.

Dupuytren's contraction of palmar fascia, showing contracted fingers.

It has been clearly demonstrated by many dissections that the fingers are held flexed by tight bands of fibrous tissue which are somewhat enlarged continuations of the palmar fascia, and which are attached to the skin of the finger at various points. It should be remembered in this connection that the palmar fascia normally is not sharply defined, but that it becomes lost in the integument along the fingers in close connection with the skin.

Dupuytren's contraction *appears first* as *a small lump* or band which can be felt in the palm near the base of the phalanx. This gradually becomes more evident; occasionally stiffness of the fingers is the first symptom observed by the patient. The condition develops slowly, without pain or discomfort, and, if allowed to progress, as is usually the case, continues until the finger-tip is drawn into the palm and other fingers begin to be involved. It is a characteristic deformity not readily mistaken. The marked flexion of one or more fingers, its progressive character, strongly resisting all efforts of extension, its slow development without evidence of inflammation, the prominent band felt in the palm, the ability to flex the finger still farther, and the absence of cerebral or spinal disease, taken together, make the diagnosis comparatively simple.

Cicatricial contractions from wounds, burns, and palmar abscess and rheumatic ankylosis with contraction, all somewhat resemble Dupuytren's contraction. The efficiency of the hand is much impaired late in the disease, but a thorough operation relieves completely.

The present TREATMENT of Dupuytren's contraction is wholly operative, and is either by subcutaneous section or by open incision, with or without removal of the contracted fascia. Massage, forcible extension, and apparatus have been abandoned as slow, tedious, and inefficient. By *operation* the contracted bands are divided subcutaneously with a tenotome at a large number of points, beginning as high up in the palm as they can be felt and continuing the incisions along the palm out on to the fingers. If the deformity is extensive, as many as ten or even twenty punctures may be necessary. The advantages of the subcutaneous method are that it may be readily done under cocaine and the

resulting scar is slight, while it has the disadvantages of all subcutaneous operations. The *open operation is the best,* for by this means the deforming bands can be clearly identified. One method is by making one or more incisions through the skin and fascia, straightening the finger, and allowing the wounds to heal by granulation. The best way of operating is to expose the contracted fascia freely by making a V-shaped incision in the palm, removing by careful dissection all of the bands, and suturing the V flap of skin back into position. The fingers should be put on a splint, which is slightly flexed to avoid pain, for a few days. Then the fingers should be completely straightened and the splint worn continuously until the wounds are healed. For several weeks, even after healing, the splint should be kept on part of the twenty-four hours—during the night if it is more convenient.

Hammer-toe is a peculiar deformity characterized by a *permanent flexion of one or more toes:* the first phalanx projects upward, while the second and third phalanges are drawn downward, so that the tip of the toe sustains the pressure on the ground. An annoying callus resembling a corn usually forms over the joint, which projects above. In many instances it is supposed to be the result of continuously wearing too short shoes, the toes being held cramped in this position: the fibres of the plantar fascia attached to the lateral ligaments become permanently shortened. In some cases the condition seems to be hereditary. The condition often begins in childhood, and continues until the deformity becomes pronounced, giving rise to much inconvenience and annoyance.

If TREATMENT is begun before the flexion becomes rigid, the trouble may often be remedied without operation. The toes should be strapped by firm adhesive plaster to a stiff plantar splint of wood or tin, the plaster passing over the crest of the projecting joint and being renewed frequently. A slight gain over the deformity is acquired each time. The lateral ligaments and plantar fascia have been divided subcutaneously and by open incision, with satisfactory results. *Excision of the joint* seems to promise a better result than amputation, for the latter to be effective must be near the metatarso-phalangeal joint.

Lock or trigger finger is the name given to the peculiar and rare condition in which free flexion and extension of the finger is prevented and the finger is brought to a sudden stop while in motion. On extra effort being made, with an appreciable jerk the obstruction is overcome and the flexion or extension is completed. The condition may be due to a circumscribed thickening of the tendon, causing for a short space a *disproportion between the size of the tendon and its sheath*, or it may be due to a small *fibroma* formed on one of the synovial fringes, being caught between the tendon and its sheath. Strains and injuries, as well as gouty and rheumatic inflammations, are regarded as etiological causes.

If after the usual means of TREATMENT by passive motion and rubbing relief is not obtained, an incision should be made and the cause of the trouble excised.

Inflammation of the Tendons and Tendon-sheaths.—The sheaths of tendons are synovial membranes which resemble very closely in structure and pathology the synovial sacs of the joints. Inflammation of a tendon is usually identical with, and occurs at the same time as, inflammation of its synovial sheath. The most frequent source of simple

hyperæmia in a tendon is a sprain or wrench in the neighborhood of a joint, or it may follow long-continued and excessive muscular exertion. This hyperæmia is usually of a subacute character and is known as **the-citis**, simple **teno-synovitis**, or **teno-synovitis crepitans**, from the peculiar well-marked crepitating or creeping sensation which is often felt over the tendon while the muscles are in action. If the injury is severe, there is an acute effusion of a considerable quantity of serous fluid into the tendon-sheath and surrounding tissues. The location of the trouble is marked by an ill-defined swelling, often elongated and cylindrical in shape, which is more or less painful and is sensitive on manipulation. Muscular action causes pain and is accompanied by the soft *crepitant feeling*. In less severe cases there may be a history of slight sprain, no distinguishable swelling, pain during fatigue or on beginning motion, which largely wears away as the movements increase and the patient becomes accustomed to them. In such instances the DIAGNOSIS is made largely by the *crepitation*, which is apt to be more pronounced than in those cases where the effusion is considerable.

This form comes on in the tendo Achilles and in the front of the ankle after long walks. The crepitation corresponds to a pleuritic rub, and is the result of a fibrinous deposit in the tendon-sheath, which becomes roughened when the tendon is moved.

The tendons of the forearm, wrist, and hand are frequently the seat of the trouble. Here it is often started up by severe muscular *exercise*, as in ball-playing or rowing or by sprains. Synovitis of the wrist- or ankle-joint may be mistaken for thecitis. In the former the pain and tenderness are diffuse, while in the latter they are elicited by direct pressure along the course of the tendon.

The TREATMENT is rest and immobilization by splints, with moderate pressure if there is swelling; later, massage and passive motion. In light cases, partial rest, tincture of iodine, blisters, douches, and light rubbing will give relief. The duration of the trouble may be from a few days to three or four weeks.

A teno-synovitis not infrequently arises in the course of acute or chronic rheumatism and in gout. Should the trouble not yield readily to local treatment, salicylic acid and potassium iodide should be administered. In connection with a *post-gonorrhœal arthritis* the neighboring tendon-sheaths are often more or less involved.

Welch has recently reported a case of gonorrhœal rheumatism at the ankle-joint in which there was extensive suppurative inflammation of the tendon-sheaths of the extensor tendons of the toes. The sheaths were distended with pus from which cultures of the gonococcus were obtained. Specific inflammation of the tendons is not common. It occurs in the form of gummata which tend to soften and discharge, leaving ragged ulcers difficult to heal.

Chronic teno-synovitis is probably in nearly every case a tubercular disease of the tendon-sheath. It may develop as a primary disease or secondarily to tuberculosis of a neighboring joint. Like tuberculosis in a joint, chronic teno-synovitis develops after some traumatism, as a sprain or contusion, and it is seen most commonly in adult life in laboring people. The great majority of cases develop in the tendons of the flexors of the forearm, while it is not of infrequent occurrence in the hand and in the vicinity of the knee and ankle. Its course is very slow,

often covering a period of two or three years, sometimes improving under rest and almost disappearing. When the patient returns to his customary occupation the disease soon recurs. The affection is always characterized by a flat or oval swelling along the course of the tendon, caused by the effusion into the tendon-sheath. Its slow development causes very little inconvenience beyond slight weakness and pain on exertion. The swelling may resemble more or less an hour-glass in shape from the confinement, in places, of the tendon beneath the annular ligament. The swelling may be distinctly fluctuating or it may be soft and elastic, while at times a peculiar feeling, simulating crepitation, indicates the presence of small, firm bodies very similar in appearance to rice-kernels. The disease tends to extend up and down the thickened tendon, to increase in size, and to attack neighboring tendons, and, when allowed to progress, even to invade underlying joints. When not primary in the tendon, it is the result of an extension from some joint in close proximity. There are *two* pathological forms of the disease. The one is a *fungous form*, distinguished by the growth of exuberant granulation-tissue of a gelatinous appearance surrounding the tendon on the inner side of its sheath. In the other form, known as hygroma, the inner surface of the tendon-sheath is covered with small growths which become detached, forming small, hard kernels known as *rice-bodies*. These rice-bodies are the result of a fibrinoid degeneration; that is, the degenerated villous growths, which are fibrinous in character, become lossened, forming free kernels.

Until recently this form of disease was supposed to have no connection with tubercular disease. It is now distinctly established that these bodies contain tubercle bacilli. The same condition may be found in tubercular joint disease, where they develop from a fibrinoid degeneration of tubercular granulations on the synovial fringes. It is said that these small tubercular nodules never become caseous. Their structure is that of fibrous tissue with few nuclei and an occasional giant cell with tubercle bacilli. Their separation is due to the fact that they project from the surface of the sheath as small, hard nodules, and by rubbing of the tendon are gradually separated. Localized tubercular areas are sometimes seen in the tendons and tendon-sheaths. If the disease is allowed to run its course, suppuration ensues, forming sinuses involving the skin which eventually break down. These, with the resulting cicatrices, greatly impair the usefulness of the hand.

The TREATMENT of chronic teno-synovitis may be of two kinds—conservative and operative. The essential features of the former are rest, immobilization by suitable splints, and moderate pressure. If the disease occurs in the forearm, the arm should be placed upon a splint, bandaged with not too great pressure over wadding, and carried in a sling. While the disease very rarely disappears spontaneously, yet this treatment, if persisted in for a long time, together with careful attention to the general physical condition, which is of the greatest importance, and the administration of tonics, iron and cod-liver oil, will often result in permanent improvement.

The writer believes that this method should be first tried in all cases which are seen sufficiently early and in which the disease has not made such progress that already an operation is indicated. This applies especially to such cases as are able to give up their occupation temporarily and devote themselves to the eradication of the disease.

The *operative treatment* is more efficient in the majority of cases.

When there is no marked thickening of the tendon-sheath and its contents are fluid, an aspirating needle may be inserted into the sac, the fluid drawn away, and an emulsion of iodoform injected. The emulsion should consist of a 10 to 20 per cent. mixture of iodoform in glycerin or olive oil, both ingredients being sterilized separately before being put together. This method of preparing the emulsion is said to prevent the dangers of iodoform-poisoning. This method of treatment will frequently result in a cure of the disease in the right class of cases.

When an *incision* is made the part should be rendered bloodless by an Esmarch bandage; the sheath should be laid open throughout the whole length of its diseased portion, even if it is necessary to divide the annular ligament, in order to thoroughly evacuate and cleanse the walls. Efficient treatment must mean the complete removal of all tubercular deposit by scissors and a sharp curette. Recognition of diseased from healthy tissue is often extremely difficult, but everything of a suspicious nature should be dissected out. This is especially true when the condition is secondary to joint disease. If necessary, the diseased tendons should be removed, and if a large portion of tendon is destroyed, the space may be filled in by splitting a portion off either end of the healthy tendon, turning the ends up and down, and suturing them together. By so doing the function of the tendon is not greatly impaired. If the operation has not been an extensive one, after thorough cleansing of the wound it may be dusted with iodoform and closed. After a radical operation the wound may be partially sutured together and packed with iodoform gauze.

While the PROGNOSIS is usually favorable in primary tuberculosis of the tendon-sheath, yet relapses occur and the patient may succumb to general tuberculosis.

Paronychia is an infective inflammation of the soft parts of the ends of the fingers, rarely in the toes, in the vicinity of, and often involving, the nail itself. It originates either in the skin itself or in the subcutaneous cellular tissue. It is usually superficial, and is seen most commonly in debilitated subjects, especially in children, after the exhaustive and infectious diseases, such as measles and scarlet fever. It occurs after a slight abrasion or wound of an infectious nature in healthy people and laboring men. Unless it is checked it spreads around and under the base of the nail, where the pus remains for a long time. It occasionally arises as the result of excessively broad or ingrowing nails.

Another form of paronychia will only be mentioned here, which is of *syphilitic origin*, being one of the late cutaneous manifestations of the disease. The results in an irregular roughened condition of the nail and frequently its permanent loss. In paronychia the inflammation is generally of a low grade and the symptoms slight, but if the infection is acute or the condition of the patient is poor, the swelling may be pronounced, the pain severe, and the suppuration profuse, with the development of fungous granulations around and under the nail, resulting in its complete loss. Neglected or improperly treated cases last for weeks until the necrosed nail is thrown off.

The TREATMENT is simple and always efficient if begun early. Incision with a small bistoury and thorough evacuation of the pus may be

accomplished without an anæsthetic. This should be followed by rest and elevation of the part, with the application of hot antiseptic fomentations of weak creolin or corrosive sublimate, changed very frequently. If the inflammation has already spread beneath the nail, the diseased portion should be carefully trimmed away, but in this event the chances are strongly in favor of its total loss.

Felon, or whitlow, is an acute infectious inflammation involving the deep tissues of the terminal phalanx of the fingers or thumb. It may originate in the soft tissues, the tendons or tendon-sheaths, the periosteum, or even the bone. At the start it is always a circumscribed inflammation on the palmar aspect of the finger, and it is more frequent in women than in men. It usually appears to originate spontaneously, but is probably the result of some injury so slight as to escape unnoticed.

FIG. 202.

Felon of thumb.

FIG. 203.

Suppurative thecitis of thumb.

The SYMPTOMS of a deep felon are almost unmistakable. The *pain* is excruciating; there is persistent throbbing which is increased by motion, pressure, or a dependent position. The finger is swollen, hot, tense, and of a livid hue. Fluctuation is not obtained, because of the limited space in which the suppuration occurs,

TREATMENT consists in *prompt incision* at the earliest moment to relieve tension by laying open the inflamed focus. This treatment should not be delayed in order to try abortive measures when once the diagnosis is clearly established. It is very rare that septic inflammation when once established can be aborted. Applications of tincture of iodine, nitrate of silver, and liquor plumbi subacetatis are recommended as abortive treatment, but the disease when recognized must be promptly relieved, for delay is dangerous.

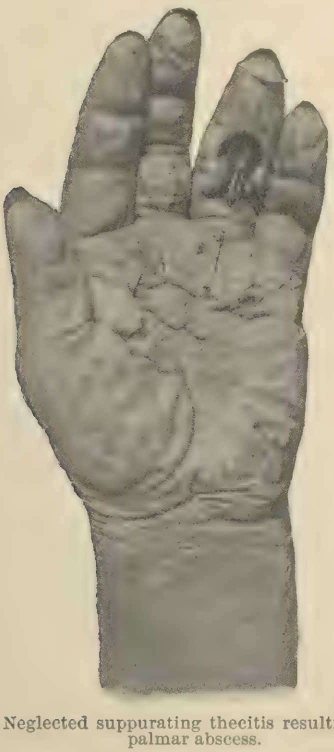
The incision may be made after applying a small elastic tourniquet around the finger and injecting a few minims of a 2 per cent. solution of cocaine into the base of the finger on either side. The incision should be made over the point of greatest tenderness, and should be carried through the soft tissues down to and through

the periosteum. Oftentimes not any or not more than a single drop of pus will be obtained, but the pain and tension will be relieved and further spread of the disease will be prevented. The incision should be made promptly, even before suppuration has been established, and the dressing should be an antiseptic one for a few days, after which the wound may heal very quickly. It is remarkable with what little discomfort the operation may be performed under cocaine, and how quickly relief is obtained.

The surgeon frequently sees neglected cases of felon which have opened spontaneously. These are very disagreeable cases to treat. The tip of the finger may be one mass of sloughing material, the periosteum destroyed, and the joint involved. It is hopeless to attempt to save the whole finger under such circumstances, but under efficient poulticing the inflammation may be reduced and the tissues brought into such a condition that an amputation may be performed later, and usually only the terminal phalanx sacrificed.

The variety of felon known as *shirt-stud* or *collar-button* abscess should not be forgotten. It is a small collection of pus lying just beneath

Fig. 204.



Neglected suppurating thecitis resulting in palmar abscess.

Fig. 205.

Same, dorsal aspect.

the skin, connected by a small sinus with a large abscess beneath the deep fascia. The danger lies in the fact that the superficial abscess may be opened while the deep one is unrecognized and continues to extend.

Pus extends readily in the finger, owing to the anatomical arrangement of the fibres, the connective-tissue fibres running perpendicularly

inward to the deep fascia, and when the pus reaches the tendon-sheath it extends without opposition along its channel.

Inflammation of the *thumb* or *little finger* is much more likely to extend into the palm and up the forearm than if situated on either of the other three fingers. The *tendon-sheaths of the first three fingers are closed sacs* and extend only to the base of the fingers, while *those of the thumb and little finger are continuous with the synovial membrane which encloses the tendons of the palm and passes beneath the annular ligament,* extending for some distance up the forearm. The importance of thorough and prompt attention to a felon can scarcely be overestimated, for an important member is involved and the function of a hand or arm may be lost, and lives have been destroyed by neglect.

Fig. 206.

Permanent contraction of fingers after palmar abscess.

Palmar abscess occurs either as the result of a *suppurative lymphangitis* or a *thecitis* of the flexor tendons of the fingers travelling upward, or it may be the result of direct local infection.

A favorite seat for infection is the callosities almost invariably seen in the palms of working-men over the heads of the metacarpal bones. The broken skin over a blister or a small crack in the surface of the skin, together with the presence of infectious matter, furnishes the soil and material for abscess-formation. This mode of infection is rather more likely to result in a superficial than a deep palmar abscess. The latter variety occurs commonly secondarily to suppuration in the tip of the thumb or little finger, where the pus has travelled along the tendon-sheaths into the synovial sac of the palm. The dense palmar fascia above, presenting a barrier to the exit of the pus, favors its spread along the tendons.

If the pressure be not relieved and an exit given to the pus, it may extend between the bones of the hand to the dorsal surface, or it usually finds its way under the annular ligament into the wrist, and frequently involves the *muscles of the forearm.* The pain and tension are always very great, while redness and inflammatory swelling are not pronounced symptoms because of the deep location of the suppuration. There is always, however, a characteristic œdematous swelling of the whole hand, which is described as a *porky* or *boggy* swelling. The fingers are stiff and held partially flexed. Fluctuation may or may not be obtained, but the other symptoms as described, of an acute nature, are sufficient to establish a positive diagnosis. There are usually considerable *constitutional disturbance,* temperature, anorexia, etc.

Nowhere is an early operation of greater importance, and neglect leads frequently to the loss of function or complete loss of the hand. Surgi-

cal anæsthesia is necessary for the operation. Incisions in the fingers and in the palm should be made parallel to the axis of the bone. Short, deep incisions are the rule, in order that the vessels may be more readily avoided. The palmar arch crosses the hand nearly opposite the web of

Fig. 207.

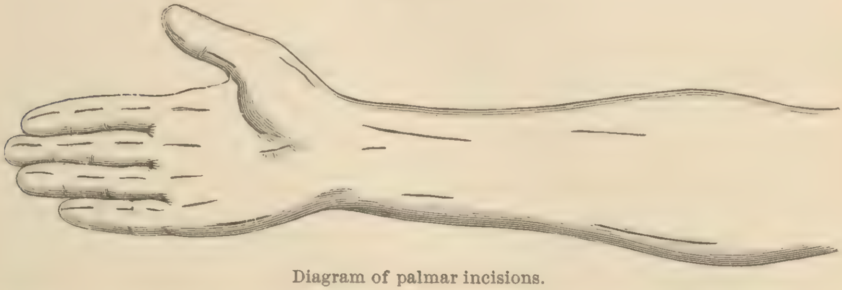


Diagram of palmar incisions.

the thumb, and if incisions are made beyond this, no difficulty will be met with. It is better to avoid cutting the arch, but if cut it should be ligated. If the inflammation has spread extensively, the sinuses should be

Fig. 208.

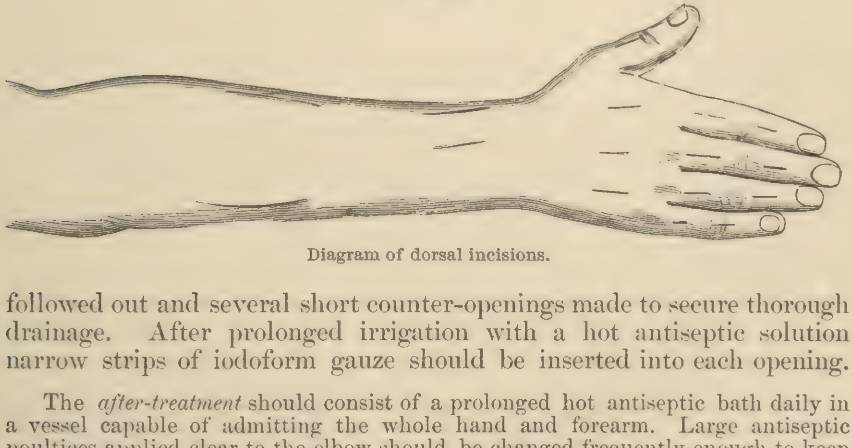


Diagram of dorsal incisions.

followed out and several short counter-openings made to secure thorough drainage. After prolonged irrigation with a hot antiseptic solution narrow strips of iodoform gauze should be inserted into each opening.

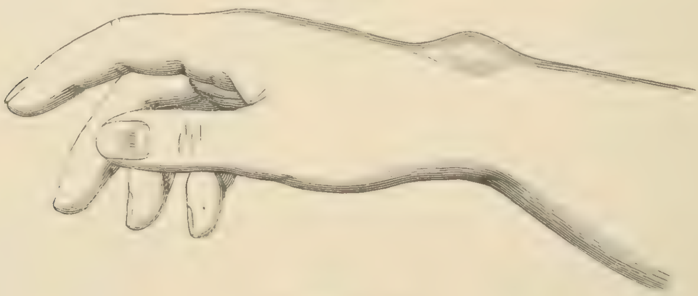
The *after-treatment* should consist of a prolonged hot antiseptic bath daily in a vessel capable of admitting the whole hand and forearm. Large antiseptic poultices applied clear to the elbow should be changed frequently enough to keep them hot, and the arm should be raised on a pillow. Careful attention should be paid to the general condition of the patient, and stimulants and quinine administered as required. In very acute types of the inflammation it may sometimes be necessary to make a number of long parallel incisions, regardless of all anatomical structures, and even to cut the annular ligament. Permanent contractures of the fingers result, due to adhesions between the tendons and to cicatricial formations. Manipulation and massage, continued for a long time after recovery, aid somewhat in reducing the contractions.

Ganglion.—In connection with the tendon-sheaths of the forearm and hand there occurs a small, rounded, elastic swelling which is known as a ganglion. It was first thought to be a localized dropsy of the tendon-sheath; hence as such it received the name of *weeping sinew.* Recently ganglia have been classed with the hygromata of the tendon-sheaths and bursæ, and now are believed to be *outgrowths from the syno-*

vial fringe or follicle of joints, occasionally from the tendon-sheaths, and are regarded as a kind of new growth. The fluid which they contain is a sort of thickened synovial fluid, and usually does not communicate with the fluid of the tendon-sheath or joint. Another theory is that the ganglion is a *hernia of synovial membrane*, occurring through a rent in the tendon-sheath, forming a closed sac.

Ganglion is most common on the dorsum of the hand, but may occur on the foot or on the flexor tendons of the forearm. It is a small, oval, fluctuating tumor, causing no pain and very little inconvenience, except that there is slight pain when the arm is fatigued.

Fig. 209.



Ganglion of wrist.

Treatment.—This is by *rupture of the sac* by pressure or treatment of the sac by *operation*. Where the ganglion is small the time-honored method of rupture of the sac by a blow from the back of a book may be tried. A simpler method is to superimpose the thumb over the tumor and by sudden pressure to rupture the sac. A splint and pad-pressure should be kept applied for ten days to a fortnight. A cure by forcibly rupturing the sac is not certain, but the method has the advantage of not injuring the patient. The treatment of the sac by *operation* may be carried out in several ways—by aspiration with a fine, hollow needle, with or without the injection of an emulsion of iodoform. In the larger tumors and in those where the simple methods of cure have failed the very satisfactory operation of excision of the sac by *dissection* may be done. In all of these methods it is necessary to apply a splint and pressure to the part in the after-treatment.

Affections of the Bursæ.

The bursæ are anatomical structures interposed between moving tissues to prevent friction, as in the case of skin or tendon over projecting bony surfaces. They are divided into two classes—the **bursæ mucosæ** and the **synovial bursæ**. The bursæ mucosæ are simple enclosed sacs containing a clear, viscid fluid, situated in the subcutaneous areolar tissue in various parts of the body, as in front of the patella over the olecranon process, over both malleoli, and in other prominent places. These are also known as subcutaneous bursæ. The **synovial bursæ** are cavities of practically the same nature and structure found interposed between muscles and tendons where they move over bony prominences. They are similar to synovial membranes, and where they exist in the neighborhood of a joint they usually communicate with its cavity. Many bursæ are present in the body at birth, but new ones are developed in consequence of friction or pressure occurring in unusual places. As the result of injury, pressure, excessive action,

and various diseased conditions, as tuberculosis and syphilis, bursæ become enlarged, thickened, and at times suppurate.

Acute bursitis is due ordinarily to *external traumatism* or excessive *muscular exertion.* It is an acute hyperæmia of the bursal sac, giving rise to increased secretions which may be either *serous*, *sero-fibrinous*, or *purulent.* It gives rise to a superficial, rounded, more or less prominent fluctuating tumor.

If the inflammation is not of a purulent nature, the SYMPTOMS are slight and are the result of physical discomfort from the presence of the swelling. When the bursitis results from a blow, the swelling comes on rapidly, with pain and tenderness, and there may be considerable blood poured with the effusion into the sac, causing so-called **hæmatoma of bursæ.** When the inflammation is suppurative, which occurs only from infection, there are rapid swelling, redness, tenderness, and pain, with often considerable constitutional disturbance. Unless promptly arrested there is danger of extension to the surrounding tissues and the joint may be invaded. The location, extent, and shape of the swelling are sufficient to distinguish the disease from ordinary cellulitis.

The general TREATMENT is rest to the part, uniform pressure, and cold applications, together with aspiration if the effusion and swelling do not diminish. If pus is present, the sac should be freely laid open, curetted out, and packed to secure obliteration of the cavity by granulation healing.

Chronic bursitis is not the mere continuation of the acute variety of the disease until it becomes chronic, but it is a distinct type of the disease which is known as **hydrops** or **hygroma.** It occurs usually as a painless, fluctuating swelling of slowly increasing size, with thickened walls due to a growth of villous or granulation-tissue, and containing a thick mucoid liquid. This villous growth at times undergoes a fibrinoid degeneration, the degenerated portions breaking loose, giving rise to the *rice-bodies* which are found in chronically enlarged bursæ. The number of these small bodies is often very large; as many as several hundred may be found in one sac. The whole process, in many instances at least, is essentially a *tuberculosis*, and in the rice-bodies are found tubercle bacilli. (*Vide* Chapter XXXIII.)

Hygromata of the bursæ are said to be caused by growths of cartilage and by sarcomatous tissue. Chronic bursitis is often due to injury or mechanical irritation, and in rare cases it is ascribed to rheumatism or syphilis. There are many cases of tubercular disease of the synovial bursæ which are secondary to a tuberculosis of a neighboring joint, and which on that account fail of recognition. It is of special importance that they be not overlooked in operations upon the joints.

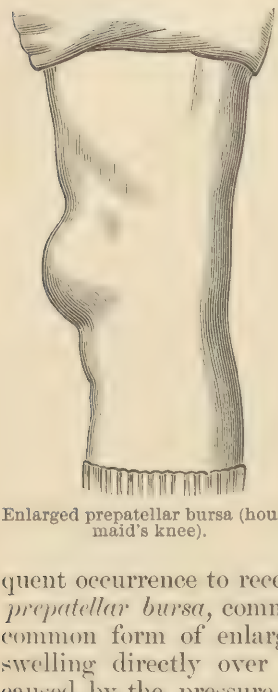
The DIAGNOSIS rests mainly upon the nature of the swelling, the slow chronic course of the disease, and the location of the trouble. In many instances when it occurs at the wrist-joint it cannot be distinguished, except by operation, from chronic disease of the tendon-sheath. Occasionally the rice-bodies may be felt like small shot in the sac.

TREATMENT other than operative is merely temporizing with the trouble, although there may occur instances in which rest of the part on a splint, with application of moderate pressure and counter-irritants, may be advisable at first and may result in temporary improvement.

The operation consists in incising the sac, evacuating its contents, thoroughly curetting out the interior, and irrigating with a 1 : 1000 corrosive-sublimate solution. If practicable, it is better to dissect out the sac. Packing with iodoform gauze secures permanent closure of the cavity by granulation. Over the *hyoid* bone a cystic tumor of a size requiring removal is rarely met with; it is a chronically enlarged bursa of the *hygroma* type.

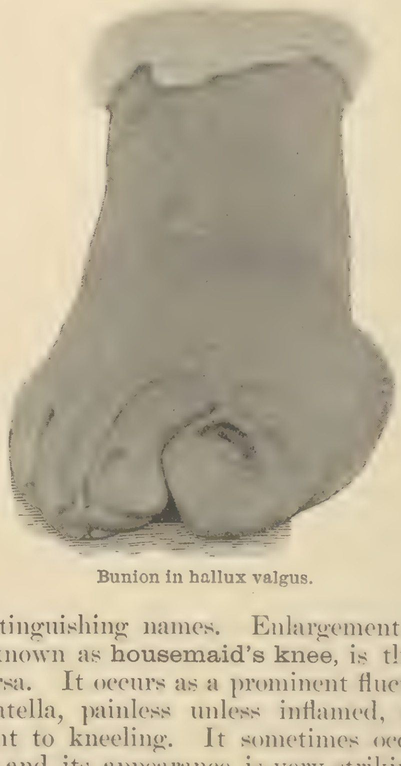
Simple Enlarged Bursæ.—There are a number of bursæ which are often enlarged. Several of them are of sufficient importance and fre-

Fig. 210.



Enlarged prepatellar bursa (housemaid's knee).

Fig. 211.



Bunion in hallux valgus.

quent occurrence to receive distinguishing names. Enlargement of the *prepatellar bursa*, commonly known as **housemaid's knee**, is the most common form of enlarged bursa. It occurs as a prominent fluctuating swelling directly over the patella, painless unless inflamed, and is caused by the pressure incident to kneeling. It sometimes occurs in both knees at the same time, and its appearance is very striking and perfectly characteristic. It should be treated by aspiration followed by rest and pressure. When inflamed it must be incised.

A bursa over the anterior aspect of the upper end of the tibia, *between the patellar tendon and the tubercle of the tibia*, is sometimes enlarged, and may be mistaken for synovitis of the joint. It may communicate with the joint and must be aspirated with care. A bursa over the tip of the *olecranon* process corresponds to housemaid's knee, and is known as *miner's elbow* from its frequency in that class of workmen. A *subpatellar* bursa has recently been described as occurring in football-players, supposed to arise from excessive exercise in kicking. Bursæ in the *popliteal* space beneath the tendons have been mistaken for aneurism as well as intra-articular disease. They are also likely to

communicate with the joint, and must be operated upon with caution. There is a deep bursa *beneath the deltoid* muscle which causes pain, swelling, and crepitation on motion when inflamed. A bursa under the *tendo Achilles* over the tuberosity of the os calcis causes pain and lameness when inflamed. A bursa occurring under the *psoas tendon*, between it and the edge of the pelvis, may communicate with the hip-joint; also one between the *great trochanter* and the *gluteus maximus* is sometimes seen: both of these when enlarged and inflamed give rise to symptoms which simulate hip disease in its early stages. Enlarged bursæ are also seen once in a great while in various other parts of the body; for example, over the *tuberosity of the ischium*, between the *latissimus dorsi and the angle of the scapula*, in the *palm*, and in the *calf* of the leg.

As a general rule, there should be but little difficulty in distinguishing bursæ, but when they lie in close proximity to a joint, the DIAGNOSIS may occasionally be quite obscure and can be made only by careful differentiation.

Bursæ of New Formation.—The number of normal bursæ in the body is very large, and is not by any means constant, even in healthy adults. As many as eighteen have been found in the vicinity of the knee-joint and fifteen in the dorsum of the hand. *New bursæ* develop in locations where the tissues are subjected to constant *pressure* or *friction*, usually over bone-prominences. They are formed in the soft connective tissue between the skin and underlying tissue, beginning at first as small, irregular cavities with a lining of atrophied connective-tissue fibres. The space develops slowly in size until finally it has a complete sac with a smooth-walled endothelial lining. Bursæ are seen in various places on the body—on the outer side of a *club-foot*, where the pressure is borne in walking; over the projecting spines of the *kyphosis* of a spinal caries; on the ends of *stumps* after amputation when an apparatus has been worn. All of these are liable to become inflamed and cause serious inconvenience. A bursa forms over the *sternum* in shoemakers; over the head of the *fibula* in tailors, constituting *tailor's ankle*, from pressure caused by sitting on the floor with the legs crossed in front. A bursæ forms over the first *metatarsal bone* in the deformity known as *hallux valgus*. This latter bursal tumor is commonly known as bunion, and always occurs as the result of wearing tight, improperly fitting, or improperly made shoes. It may be caused by the shoe being too loose, allowing the foot to slip back and forth, or more frequently it is due to a narrow-toed shoe causing the tip of the great toe to bend toward the outer side of the foot, thus bringing unusual pressure on the joint. A mild degree of bunion is present in many people who suffer very little inconvenience. There is usually slight tenderness in the part, and the swelling is quite likely to become acutely inflamed, in which case the skin becomes much reddened; there is constant pain with excessive tenderness, walking is very difficult, and it is impossible to wear a boot of any kind. Suppuration takes place in the bursa, which, breaking through the sac, invades the joint and other tissues and often starts up a cellulitis in the foot. Persons having bunions should not wear narrow-toed shoes, but shoes with broad, rounded toes and a straight inner border.

Bunions which are slightly inflamed and in which there is some pain and discomfort are relieved until the acute symptoms have passed off and the inflammation has subsided by wearing over the part a small, circular felt pad cut out in the shape of a washer. The pressure of the shoe comes against the pad, which surrounds the sensitive area. If the bursa is thickened and not inflamed, blisters and iodine may be applied to reduce its size. When the bursa is inflamed rest and cooling applications are indicated and may prevent serious trouble. Suppuration demands incision and antiseptic treatment, and if the joint is invaded partial or complete excision of the joint will be required. The removal of a bursa before any inflammation has occurred is the best treatment, and frequently it is necessary to combine with its removal a resection of the underlying joint.

Tumors of Muscles.—Primary tumors of muscles are of comparatively rare occurrence, and when found are treated as elsewhere. They may be located in the muscle itself or in its tendon. Aside from those of syphilitic or tubercular origin, which have already been spoken of, those of sarcomatous type are the most common, while fibrous myxoma and enchondroma are occasionally seen. Secondary infiltration or deposit in the muscles is common when the growth originates in a neighboring part. This often occurs in the pectoral muscles from cancer of the breast. Primary tumors of muscles can be readily removed, and their recurrence depends on their malignancy. Secondary tumors should be operated on as a palliative measure.

Parasitic cysts of muscles are rare. The *trichina spiralis*, the *echinococcus*, and the *cysticercus* are the three varieties of animal parasites which occasionally occur in muscles.

Trichinosis originates from eating underdone pork which contains the trichinæ spiralis. These parasites develop in the intestines, penetrate the walls, and enter the circulation, or by a direct passage find their way into the muscles, where they remain. By their presence a myositis develops, resulting in exudation, which becomes encapsulated and forms a permanent cyst.

The SYMPTOMS are pronounced: there is a muscular stiffness, with pain, swelling, and tenderness. The constitutional symptoms are high temperature, chills, delirium, and gastro-intestinal disturbance. The mortality is high, but undoubtedly many mild cases recover.

The DIAGNOSIS is confirmed only after abstracting a piece of the muscle with a small punch and subjecting it to a microscopical examination.

The TREATMENT consists of the employment of purgatives; sedatives, ample nourishment, and stimulants are required.

The *echinococcus*, or hydatid, and the *cysticercus* are seen even less frequently than the trichinæ, which they closely resemble in character. They result from infection by tænia through the intestinal tract. Their presence in the tissues through irritation results in the formation of cysts. These parasites are not confined to muscles, but are found in any tissue or organ of the body.

Tenotomy and Myotomy.

These should be recognized as important surgical operations, as upon them depend largely the correction and removal of many deformities. They form a considerable proportion of the operative surgery of orthopædics, but are frequently very useful to the general surgeon. *Myotomy* and *tenotomy* will be treated as one subject, because the method of operating is essentially the same. It is always advisable to cut the tendon when possible, and only in instances where the muscle has no tendon or the tendon is too short is the muscle itself divided. Tenotomy is

indicated in all cases where there is permanent contraction or shortening in a muscle or fascia, resulting in deformity which interferes with the usefulness or beauty of the part. In fractures occurring in the neighborhood of a joint persistent muscular spasm may interfere with maintenance of apposition of the fragments. This may readily be overcome by subcutaneous tenotomy. This is often true of the tendo Achilles in fractures about the ankle-joint. There are two ways of performing tenotomy—one by an *open incision*, the other *subcutaneously*.

In general, it may be said that the open operation is desirable in dangerous localities and where there are several tendons to be cut, as in the case of contraction at the wrist-joint. The advantages in favor of subcutaneous tenotomy are its simplicity, greater rapidity in securing firm union, and minimum danger from infection by the small puncture. The operation of subcutaneous tenotomy is easily done, and there is little danger if a thorough knowledge of anatomy is possessed by the operator, in order that important vessels and nerves may be avoided. The only instruments needed are two delicate knives, known as *tenotomes*, with straight blades about a half inch in length and an eighth of an inch broad—one sharp-pointed, the other blunt. Longer blades are unnecessary, except in rare instances where a muscle is to be divided. The curved tenotomy knives, while theoretically applicable to the curved surface of the tendon, are, in the experience of the writer, never necessary. The sharp-pointed instrument should be introduced through the skin near the tendon, and above or below it according as one desires to cut in or out. By cutting the tendon outward the skin is more likely to be punctured, while by cutting downward there is more danger of injuring adjacent and underlying structures.

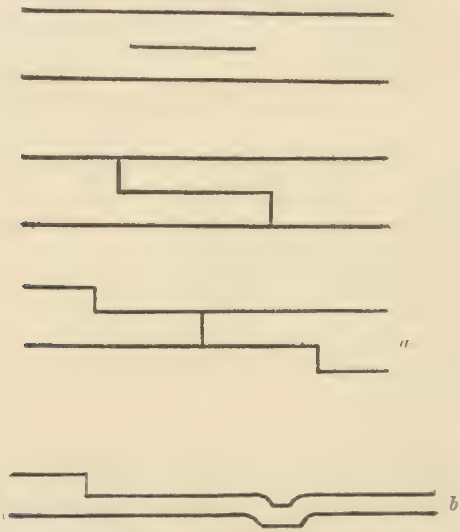
In the hands of skilful men, accustomed to the performance of tenotomy, the sharp-pointed instrument, which is designed merely to prepare the way for the blunt tenotome, is often used to divide the tendon. It is safer, however, to use the blunt instrument for this purpose, especially in the neighborhood of important structures. As the tendon is divided a creaking sensation is felt and the tendon gives way with a distinct snap. A common source of failure in this operation is due to the incomplete division of the tendon or its sheath. After the withdrawal of the knife the blood should be expressed from the wound and a simple *antiseptic dressing* applied for a few days. The technique of the particular operations for the various deformities requiring tenotomy will be found under their several headings.

The open division of tendons is to be preferred in many cases: with the limb rendered bloodless and a clean incision over the tendon which is to be divided, it is very satisfactory to simply snip the tendon, with its sheath, with a pair of blunt scissors; no unnecessary damage is done to the surrounding parts, the divided skin is easily adjusted by a few sutures, and the wound is dressed antiseptically.

Lengthening of Tendons.—In certain cases where the contracted tendon is to be divided it may be advisable to lengthen it a certain definite amount. This may be done, as illustrated, by an incision along the middle of the tendon, which should be one-half as long as the required distance. The tendon is then cut through at either end of the middle incision and the ends sutured together. Another method of lengthening, especially applicable to old cut tendons where the ends are retracted and cannot be brought into apposition, is by splitting off a por-

tion of one or both ends of the cut tendon, turning it down, and suturing together the ends thus split off.

FIG. 212.



Showing methods (*a*) and (*b*) of lengthening tendons.

Transplantation of muscles and tendons, in the absence or loss of

FIG. 213.

Illustrating transplantation of tendons in paralytic valgus (case of Dr. J. E. Goldthwait): *A*, before operation, with patient standing naturally, bearing weight on both feet: *B*, after operation, showing patient standing and bearing all of weight on left foot.

tissue, has been proposed, and experiments have been made on animals

with this end in view. It has been shown that such implanted tissue always becomes absorbed, but it is possible that such tissue may assist and hasten regenerative changes. Gluck has inserted strands of catgut to replace the loss of muscle, of tendon, and of nerve-tissue, with partial success.

Dr. J. E. Goldthwait of Boston has recently suggested a new method of **tendon transplantation** or **grafting**, and several cases have been operated upon and reported by him. It is made use of in the treatment of some cases of infantile paralysis for the purpose of furnishing better mechanical support to certain partially paralyzed groups of muscles. The method consists of cutting the tendons of certain muscles and attaching them to others, and thus transferring the action of the muscles to other more important tendons. From the few cases which have already been operated upon the writer believes this to be a surgical procedure of considerable promise in the treatment of deformities resulting from infantile paralysis.

CHAPTER XXX.

INJURIES AND DISEASES OF THE LYMPHATIC VESSELS AND NODES.

By Frederic Henry Gerrish, M. D.

The distribution of lymphatic structures is so extensive that, whatever a morbid process is or wherever it exists, it is almost sure to involve some of them. Although not commonly so regarded, the spaces enclosed by the great serous membranes are only prodigiously expanded areolæ or lymph-spaces, and the deep layer of many mucous membranes is composed of essentially the same material as that which constitutes the most typical node, only in the one case it is diffused, and in the other gathered into a definite mass. Certain viscera are often included in the enumeration of the organs of the lymphatic system on account of the conspicuousness of characteristic elements in their structure. But this chapter will deal only with the affections of the lymphatic system in general, and with the most of those in which the principal feature is the involvement of lymphatic vessels or nodes, or both.

It may not be amiss to call attention to the important part played by the lymphatic system in many conditions of disease. Nearly everywhere there are minute spaces between the histological elements of which the tissues are built. These irregular, microscopic, and innumerable crannies are the beginnings of streams which flow unceasingly toward the central ends of the great veins which empty into the right heart: they are the finest rootlets of the great trees whose branchless trunks are the thoracic and the right lymphatic ducts. Some of these tiny spaces are exposed on every surface which is artificially made either by accidental or intentional wounds, and in such circumstances afford the best possible opportunity for the introduction of pathogenic micro-organisms into the system. But a breach of integument is not absolutely necessary for the admission of the germs of a disease, for *lymph-spaces* are so near the cutaneous and mucous surfaces that prolonged contact, and especially contact with pressure, is often sufficient to effect the penetration of the intervening layers by the microbes and ensure their entrance into the lymphatic system. Thus, *septic poisoning may come from immersion of the unwounded hands in the fluids of a cadaver at a necropsy, and syphilis may be contracted by the mere touch of the discharge from an initial lesion upon a moist and delicate part of the unbroken skin.* While it is important, therefore, that we should search for an opening at the periphery of the set of lymphatic vessels which drains into the node or group of nodes whose involvement is a feature of the malady which we are investigating, we cannot always find evidences of even the slightest injury. To be adequately equipped for the study of lymphatic diseases one needs a high degree of familiarity with the anatomical relations of the vessels and the nodes to which they are tributary.

Wounds of Lymphatic Vessels.

Probably every cut into the tissues beneath the epithelial surfaces lays open minute lymph-vessels, and in amputations tubes of considerable size are always severed. But almost never does any trouble ensue from such injuries alone. If a superficial vessel does persist in leaking through a wound, a delicate touch with a mild caustic and firm com-

pression with pad and bandage will usually speedily end the trouble. But when a *great trunk* is incised or otherwise opened, the surgeon has to deal with a lesion of the gravest kind. The *thoracic duct* is so deeply located that it is very seldom wounded, but when it is punctured the very inaccessibility which is ordinarily its protection interferes with, though it may not absolutely prohibit, direct treatment. Its contents escape into the whole surrounding region, causing *chylous hydrothorax* or *chylous ascites*, or both, or the fluid may distend the areolar tissue outside of the pleura and peritoneum or fill up the mediastinum.

Possibly a cure may be effected by an abdominal section with drainage, adhesion of the lips of the duct resulting from the irritation occasioned by the necessary manipulations during the operation and by the presence of the drainage-tube. *Suture* of the opening in the thoracic duct seems not to have been attempted in the abdominal region, but it has been tried with success in the case of wounds close to its central extremity at the base of the neck. In this locality forcipressure and compression with a pad of gauze have yielded good results.

Wounds of the *right lymphatic duct* are far less serious than those of the larger trunk, and, from its readier accessibility, are much more amenable to treatment.

In conjunction with the means already recommended, and also when they cannot be employed, it is advisable to keep the patient perfectly quiet and on the lowest diet compatible with living. Fluid food should be avoided as far as practicable, with a view to preventing distention of the injured vessel. Death, which may be long delayed, will probably result from inanition, but a fatal result is not inevitable, a number of spontaneous recoveries having been reported.

Inflammation of Lymphatic Vessels.

Lymphangitis, as this disease is technically called, need not be described under several different heads, as has usually been the case, for we now know that all inflammation of lymph-vessels is of microbic origin, and may therefore drop the terms "idiopathic" and "traumatic" as being no longer descriptive. Lymphangitis is almost always secondary to some traumatism, but it may depend upon the passage of septic matter through the unbroken integument. It may be induced by various micro-organisms. At first a thrombus is formed in a vessel; then pus-cells are seen in the walls, the epithelium is swollen or peeled off, the lymph is thick with desquamated cells and fibrinous clots, leucocytes and exuded lymph surround the tube, and the neighboring structures are inflamed. In tubercular inflammation characteristic deposits occupy the lumen. The process may terminate in complete resolution or abscess or occlusion. The related nodes are usually implicated.

When only the minute vessels which form a fine network near the surface are involved the inflammation is called *reticular;* when only the larger collecting vessels are concerned it is called *tubular;* but both forms may coexist.

The DIAGNOSIS of deep lymphangitis, where no superficial inflammation is present, is not always easy; indeed, it is usually very difficult at first on account of the distance of the affected vessels from the surface.

Clinically, we observe in mild cases of the *tubular* variety faint red lines in the skin coursing up the limb, which are felt to mark the location

of beaded cords. From these a bluish tint diffuses laterally, and the nodes soon become swollen and tender. Little pain is experienced if entire quiet is maintained. In severe cases all these symptoms are aggravated. Pain is acute, fever is high, œdema is marked, and in some situations is very perilous. Later on pus forms in the nodes and areolar tissue, and in the worst cases there occur rigors, excessive thirst, diffluent abscesses in distant parts, restlessness, delirium, and death from *septicæmia*. The termination of a case depends upon the nature and amount of the toxic material introduced, the condition of the patient, and the promptness and wisdom of the treatment.

In the *reticular* form the inflammation shows itself in red, tender, œdematous patches, which may succeed each other up the limb, one fading as a neighboring area blooms out. It is to be remembered that the inflammation of a vessel, superficial or deep, does not always pursue a course from periphery to centre: it sometimes works back in the opposite direction.

TREATMENT must be both local and general. If there is a wound, thorough disinfection of it must be effected at once. Irrigation with an antiseptic wash may accomplish this, but if this is doubtful the wound should be laid open to give opportunity for perfect cleansing of the parts. For a surface application a hot *antiseptic pack* is best in the early stages; for example, a corrosive-sublimate solution, 1 : 2000. A blister around the limb at a level proximal to the disease was much esteemed formerly —*i. e.* fighting fire with fire. If pus forms or is suspected, incise freely and let it out. Meantime the systemic condition must be regarded, the bowels and kidneys kept active, pain checked with anodynes, and the strength held up with easily digested food and other supportives.

OCCLUSION OF LYMPH-VESSELS.

A considerable number of the most serious affections of the lymphatic system are caused by *interference with the normal flow* of lymph; and, as many of these diseases have features in common, it will be well first to study the general subject, and then to consider in detail the specific manifestations, varying as they do according to their etiology, their situation, the size of the vessel involved, and the kind of tissues concerned.

Various conditions occasion occlusion, as thickening of the walls of the vessels from inflammation, the deposit of plastic material about the tube, the pressure of neighboring tumors, the presence of a morbid growth within the lymphatic, or the lodgement of a parasite in its lumen. Anything which arrests the current dams back the lymph upon the region which the vessel normally drains, unless the fluid can escape by some side channel; and this interference results usually in one or both of two principal changes. The first of these is *dilatation* of the vessels from the increased pressure of lymph within, and the other is *saturation* of the tissues on the distal side of the obstruction with lymph, and their consequent hyperplasia from over-nutrition.

Dilatation may be displayed over a minute area or in the vessels of an entire limb—there may result small vesicles or large cystic tumors; it may affect deep structures or superficial; its effect on health varies from the inappreciable to the destructive; and its amenability to treatment ranges between the facile and the hopeless. If the case is one of pure dilatation, the vessel assumes a beaded appearance when the valves hold,

and a cylindrical when they do not. The latter variety readily changes into the cystic when the inward pressure is concentrated upon a limited area, and causes a bulging of a part or the whole of the circumference. When a cluster of dilated vessels lie in contact, increasing pressure may cause such atrophy of their contiguous walls that ultimately perforations occur, and the mass of tubes becomes a sac with imperfect septa which are the remnants of the vessel-walls. Inflammation of a dilated vessel is a much more serious matter than the same process in normal conditions.

The hyperplasia resulting from the constant overfeeding of the parts, which are flooded with lymph in cases of occlusion, is not observed in all of the tissues; but the *white fibrous*—the classical "connective-tissue proper," the material which nature uses so largely in reparative processes and which is produced so readily—gluttonously appropriates as much as it can of the excess of nourishing material, and, having a greater capacity for growth than its neighbors, crowds them to such an extent by its augmented bulk that they are not able to take even their wonted quantity of aliment. As a consequence they suffer atrophy, while it undergoes hypertrophy. It is a case where the greedy avarice of the rapidly-breeding plebeian starves out the refined and sensitive, but necessary, patrician, with the usual result of fatal disaster to the community.

Lymphangioma.

Lymphangioma (*vide* Chapter XXVI., Group VI.) is a tumor of which the essential constituent is dilated lymphatic vessels. As a rule, it is congenital. It occurs most frequently on the neck, buttocks, back of thigh, groin, axilla, forehead, and in the mouth. It is painless, soft, and compressible. As the size of the tumor increases by further dilatation of the vessels the connective tissue between them atrophies and disappears, and then the vessel-walls are thinned, and, to a greater or less extent, absorbed, so that free communication is established between the various tubes, and a lymphatic cyst is formed. Sometimes a contiguous blood-vessel is invaded by the same process, and, the contents of the two kinds of vessels being mingled, we have a *hæmato-lymphangioma*—that is, a tumor composed of blood-vessels and lymph-vessels. The so-called *cystic hygroma* of the neck is a *cavernous lymphangioma.* It occurs just beneath the occiput, is smooth, and is marked by a vertical median groove. Another variety of lymphangioma is *lymph-varix.* When this occurs as a superficial growth its favorite sites are the penis and the groin. It is often only a temporary formation, disappearing with the removal of the obstruction which has caused it. The deep varices are much more serious. They commonly occupy inaccessible positions in the abdomen. In the advanced stages they may be mistaken for herniæ.

Structurally considered, all the varieties of lymphangioma are benign growths, but in certain circumstances their presence may be a menace to life. The continuous internal pressure to which their walls are subjected sometimes occasions spontaneous perforations, and the accidental application of external violence may produce the same effect. The leakage of lymph through such apertures is often enormous, and, while cases have been reported in which great loss of this fluid has been en-

dured without serious impairment of health, there is danger of the establishment of grave anæmia. A moderate but persistent discharge is called *lymphorrhœa;* a large and continuous one, *lymphorrhagia.*

Treatment of superficial varices should be directed to the removal of the cause if possible. The deep varices should be studiously let alone, for they cannot be wholly removed, and if wounded leak most alarmingly. Other lymphangiomata should be removed with absolute thoroughness if subjected to any treatment.

Lymphœdema.

Interference with the normal passage of lymph often results in its transudation in large quantity into the areolar tissue. This condition is called *lymphœdema* or *solid œdema.* It is distinguishable from the œdema which results from venous obstruction by its extreme density and persistence. Areolar tissue is so almost universally a constituent of the soft parts that lymphœdema may affect a whole limb, which then becomes brawny, inflexible, and enormously swollen. If this condition exists a long time, permanent enlargement ensues from the growth of white fibrous tissue, and the part becomes not only useless, but an intolerable burden.

The treatment should aim to remove the obstructing cause, if practicable. If this cannot be done, firm, equable compression with an elastic bandage should be applied. This failing, nothing remains to be done short of removal of the affected part. Amputation-flaps may heal promptly, even though lymph oozes profusely from their cut surfaces at the operation.

Macromelia.

Sometimes we see cases in which there is no typical lymphangioma, varix, œdema, or lymphorrhœa, but for which we can account only on the ground of occlusion of lymph-channels, as there is a monstrous growth of one or more members, obviously from such excessive nutrition as is a characteristic feature of this obstruction. This condition is known as *macromelia,* but special names are used for the designation of the disease in different parts, as *macrodactylia, macropodia, macroglossia,* and *macrocheilia,* wherein the digits, the foot, the tongue, and the lips are respectively affected (see Fig. 166).

Fig. 214.

Macroglossia (Neisser).

The patient shown in Fig. 215 was affected in two fingers of one hand and three of the other, and in one leg, the part of the limb most overgrown being the great toe.

The cause of the disease is unknown, and the only satisfactory treat-

ment is amputation. (*Vide* also Chapter I., Tissue-Alterations due to Change in Nutrition.)

FIG. 215.

Macromelia (original).

CHYLOCELE.

This disease resembles ordinary hydrocele in all of its clinical aspects with a single exception, which is rarely, if ever, recognized before operation. The fluid contents, instead of being clear, are milky, and *failure to find translucency* in a case supposed to be one of hydrocele should *excite suspicion of chylocele.*

A positive DIAGNOSIS, however, can hardly be made, as the rare disease, spermatocele, presents a non-translucency with the candle-test. The fluid in chylocele is *milky*, and if allowed to stand cream rises to the surface. The lining of the sac may exhibit distended lymph-vessels, or at some point the mouths of several large channels connected with spaces of areolar tissue. Apparently the disease is due to an obstruction on the proximal side of some lacteal, but the pathology is not clear. Further observation may show this to be of filarial origin.

TREATMENT for hydrocele is generally that appropriate for chylocele; but in cases where milder means fail it will be well to lay open the vaginal tunic and ligate the enlarged and leaking vessels.

FILARIASIS.

Most prominent among the causes of serious obstruction of lymph-channels stands *filariasis.* The diseases which it induces are uncommon

in this country, but it has already obtained a foothold in some of our Southern States, and the possibility of its wide dissemination gives a peculiar interest to the study of its history and manifestations.

It is essentially a parasitic condition. In a typical case of filariasis the blood contains a multitude of worms of the nematoid class of the variety called *filaria sanguinis hominis*—the thread-like worm of the blood of man. The creature is sexless, one-eightieth of an inch long, not quite as wide as a colored corpuscle of the blood, and wriggles incessantly like a snake.

The worm appears to be enveloped in a filmy, transparent sheath, within which the body is alternately extended and retracted with great rapidity, so that the impression is produced of the animal's being furnished with a lash. This action does not cause locomotion, but makes little currents in the blood, by which the recognition of the parasite is facilitated. Many millions of these microscopic beings may exist in one patient. A most peculiar characteristic is their alternate presence in and absence from the blood. During the daytime the blood is free from them, but as night approaches they begin to appear, their numbers rapidly increase, and by midnight the blood swarms with them. From this hour they gradually disappear, and few, if any, can be discovered after six o'clock in the morning. Habitual reversal of the periods of waking and sleeping determines a corresponding change in the time of appearance of the parasites, and fever interrupts the regularity of their manifestations. The cause of the periodicity of their migrations is not known.

These creatures are the embryos of a worm, the *filaria Bancrofti*, which has lodged in a lymph-vessel. The male of the species is probably a close companion of the female. The latter is about three and a half inches long and one-ninetieth of an inch thick. It has a smooth body, a clubbed head, a slender neck, and a blunt tail. Its alimentary canal extends from the head nearly to the tail, but the greater part of the body is occupied by a bicornous womb which is crammed with embryos. The animal is viviparous, and its young, being borne into a lymph-channel, are carried by the current through the thoracic duct into the blood-vascular system.

The method by which filariæ are propagated is of practical interest. A female mosquito abstracts from a person who has filarial disease a meal of blood in which are many of these embryos. Several days are consumed in the digestive process, but a small proportion of the parasites not only escape destruction, but even undergo some development. The insect, led by instinct to deposit her eggs on the surface of some pool, ends her brief life by falling into the water, and the tenants of her frail body emerge into a medium exactly suited to their needs. In this they may attain a length of half an inch. If now they are swallowed by a human being whose thirst for water exceeds his discretion in the selection of it, they work their way, probably by boring through the intermediate structures, from the alimentary canal to some large lymph-vessel, in which they find the environment best adapted to their comfort. They then steer against the current of lymph, and continue until they enter a vessel too small to permit further passage. Here a permanent lodgement is effected, and the creatures grow, develop, and breed in their snug quarters for years, setting up serious structural changes in the neighboring parts by the irritation of their presence.

Several mature worms have been discovered in a single case. It is imaginable, however, that one of these helminths could produce pathological results of the gravest sort. While it is unquestionable that nearly all cases of the various diseases which are called filarial are really inaugurated by these parasites, it is possible, on the one hand, that some other equally obstructive agency may produce identical results, and, on the other hand, it is known that filariasis may exist for a long time without serious interference with health. Both of these occurrences are, however, exceptions to a very general rule.

No evil results are to be expected from the mere presence of the *embryos* in the blood, but the *parents* are terribly mischievous in their effects. Hyperæmia, organization, and consequent stenosis, of the invaded

vessel are soon occasioned; the lymph is dammed back, the tube dilates, the walls burst or become hypertrophied, the whole region which was formerly drained by the occluded vessel is saturated and distended with the fluid, and the tissues undergo characteristic changes. *Lymphangitis, lymphadenitis, lymph-varix, lymph-scrotum, chyluria, elephantiasis, phlebitis, hæmaturia, hydrocele, fever resembling malarial*,—one or several of these are to be anticipated in such a case.

It is useless to direct any medicinal agencies to the *cure* of filariasis. Even if we knew how to destroy and remove the unwelcome visitor, its extirpation would do no appreciable good, for the lesions produced by the presence of the worm would remain. Something of alleviation may perhaps be accomplished by rest, elevation of the affected part, the lowering of tension by the use of saline laxatives, a spare diet, and abstinence from liquids as far as possible. Operative procedures are sometimes available, and these will be mentioned when considering the separate diseases caused by filariasis.

Our greatest reliance in our efforts to rid the community of the evils dependent on this parasitic condition must be placed on *sanitary measures*. If all drinking-water in filarial regions were to be subjected to thorough filtration and boiling, or to either of these processes, the further extension of the condition would be effectually prevented.

We now proceed to the consideration of the chief diseases produced by filariasis.

ELEPHANTIASIS.

No one who has seen a pronounced case of elephantiasis of the lower limb—a favorite seat of the disease—would think of questioning the fitness of the name, for the resemblance to the leg of the greatest of quadrupeds is instantly suggested. The disease is not common outside of the tropics, and yet cases are seen now and then in northern climes. As our knowledge of filariasis is quite recent, it is impossible to state whether or not most of the sporadic instances apparently originating in the temperate zone have had a filarial source. As the mature parasite has a marked preference for the lymphatics of the lower part of the body for residential purposes, the disease is rarely seen above the navel, and the lower extremities and the external genitals are the members usually affected.

When the malady attacks the lower limb it commonly begins with an outburst of erysipelas in the *toes*. The manifestations are not unusual—pain, swelling, inflammation of lymph-nodes, systemic disturbance. Subsidence leaves the integuments thicker and harder than normal. After a variable period a second attack of erysipelas occurs over a wider area and disappears, and then another and another, and so on for many times, each leaving its mark in a contribution to the thickness of the skin and subcutaneous tissue, until the hypertrophied parts may be four inches thick. The limb is rarely involved above the knee. When the disease is well marked the skin is seen to be thrown into many ridges, the surfaces concealed in the intervening furrows being eczematous; foul and indolent ulcers are numerous; and cracks, oozing lymph, appear at many points. The skin may be

smooth or rough, hard or soft, and gray, brown, black, warty or knobbed, and a single case may display several of these peculiarities. The suffering of the patient is mainly due to the great weight of the member, but in some cases the pressure upon included nerves adds an element of very acute pain.

The condition now established is a true hyperplasia of the white fibrous tissue of the corium and subcutaneous areolar layer, in the interstices of which is a copious albuminoid deposit. The papillæ are immensely enlarged. A section shows a white, homogeneous mass, moist with lymph, which leaks from every point, and almost as dense as cartilage. The blood-vessels are notably enlarged. Pressure and enforced inactivity have caused degeneration of the muscles, and the over-nutrition of the periosteum has resulted in abnormal growth of bone, usually in disfiguring protrusions.

FIG. 216.

Elephantiasis of leg, scrotum, and penis (original).

FIG. 217.

Elephantiasis of hand, acquired (Park).

TREATMENT OF THE ERYSIPELAS should be conducted on the lines already prescribed for that disease, and the other incidental ailments are to be managed as when they occur in other circumstances. For the fully-developed elephantiasis *numerous therapeutic recommendations* have been made. Rest, elevation of the limb, and fomentations contribute to the comfort of the part; compression with a rubber bandage may retard the growth and afford some relief for a time; anodynes and supportives to the general system are often manifestly demanded. But among real operative measures *amputation* alone is worthy of serious consideration, and must be resorted to if the disease is to be extirpated.

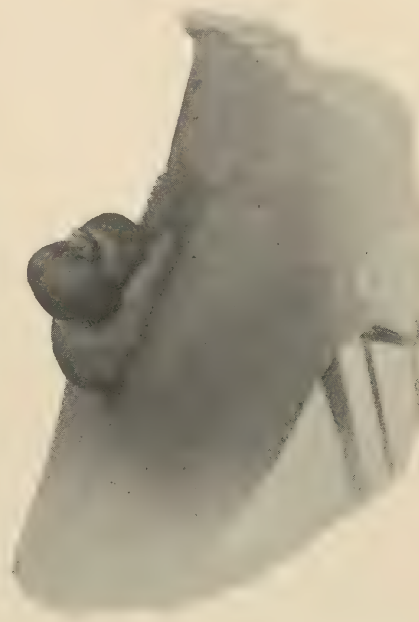
The results are generally all that could be expected. The Esmarch bandage is of conspicuous value in these cases.

Elephantiasis of the external genitals stands next in order of frequency to that of the leg, and, allowing for the structural differences in the organs concerned, the symptoms and the tissue changes are substantially identical in the two localities. If only the scrotum is involved, its integuments so far outgrow the length of the penis that the latter may become lost to sight at the bottom of a conical pit. The superficial lymphatic vessels are apt to become varicose, and, being ruptured, discharge so much fluid as to keep the skin moist. Ulcerations are common, and mortification of the mass may occur. The chief danger seems to be from septic infection. The greatest discomfort experienced is due to the bulk of the tumor and its weight, which may exceed that of the individual who bears it. The severe dragging on the inguinal structures not infrequently causes hernia.

Fig. 218.

Elephantiasis of scrotum (original).

Fig. 219.



Elephantiasis of scrotum and penis (original).

When the penis is the part principally affected, which is rather uncommon, it may grow to a monstrous size. In Fig. 216, which exhibits a typical enlargement of one leg, the patient's penis, measured around the curves, had a length of twenty-seven inches and a circumference near the scrotum of fifteen inches. This case and that represented in Fig. 218 belonged in Barbados, where the disease is so common as to have derived one of its names (*Barbados leg*) from the place. Fig. 219

is drawn from a photograph of a New England case in which penis and scrotum are about equally diseased.

In females elephantiasis is far less frequent than in males. The genitalia involved are the homologues of the scrotum and penis—namely, the labia majora and the clitoris.

The TREATMENT OF ELEPHANTIASIS OF THE GENITALS does not differ from that appropriate to the disease in other localities. Only complete ablation affords anything more than transient relief. The main peril is from shock, for hemorrhage, which formerly was most dreaded, is largely controllable by the Esmarch bandage. For some hours before the operation the parts should be elevated in order to drain them of fluids, herniæ should be reduced, and hydroceles emptied. The neck of the tumor is to be constricted with the elastic band and provision made for compression of the aorta. The incisions are made along the dorsum of the penis and over the course of the cords, and these organs, with the testes, are dissected out and turned up on the abdomen. Wounding of the vaginal tunic is to be avoided. The perineal connections are then severed and the mass removed. Veins, as well as arteries, ought to be tied.

LYMPH-SCROTUM.

This is a form of elephantiasis, and often develops into the commoner variety. It generally is ushered in with fever, which is quickly followed by acute inflammation of the scrotum and of the lymphatic vessels of the groin. The skin is thickened and becomes peculiarly corrugated, and its lymph-vessels dilate to such an extent as to constitute a set of large intercommunicating sinuses, with so little epidermal covering that spontaneous or artificial perforation often starts a dangerous lymphorrhagia. The scrotal enlargement is more due to dilatation of lymph-vessels than to hyperplasia of connective tissue. Usually there is intermittent leakage of lymph, and the bulk of the tumor may lessen during the discharge and increase during the interval. After the drain has continued for many years it may cease, and the scrotum gradually assume the characteristic appearances of ordinary elephantiasis.

Filariæ may be absent from the blood, even though constant in the voided lymph—a condition brought about by the lodgement of a worm in a vessel in or near the upper part of the scrotum. The inflammation which the parasite awakens extends to the nearest related nodes, the channels of which consequently become occluded, and thus the embryos are confined in the lymph on the distal side. Ablation is the only suitable treatment.

CHYLURIA.

This is a condition characterized by the presence of *emulsified oil in the urine.* There is usually no warning of its approach, but the onset is sudden, the urine assuming a milky look and becoming extremely abundant. Simultaneously there may be discomfort in the region of the urinary organs, with general depression and debility. The urine coagulates quickly, but the clot soon disintegrates, a layer of cream forms on the top, and rapid decomposition ensues. There is sometimes coincident hæmaturia. Chyluria may continue many months, and then cease as

abruptly as it began. It is often associated with lymph-scrotum, and the discharge of milky fluid from the ruptured vesicles may alternate with the appearance of chyle in the urine. The condition of the general health varies greatly, but marked debility is common, due probably to the waste of a large amount of the digested materials which the lacteals have absorbed.

The PATHOLOGY is obscure. Doubtless the disease is of filarial origin, for its geographical distribution is identical with that of other diseases of this class, and the embryos are almost invariably to be found in the blood and in the chylous urine. No other feature of the malady is as constant as their presence.

Supportive measures are almost always demanded, but beyond this TREATMENT nothing avails.

PROGNOSIS should be guarded.

Inflammation of Lymph-nodes.—Now-a-days we have discarded the words "idiopathic" and "diathetic" as applied to this disease, for we recognize no spontaneity of cause to justify the first, and know that the cases which formerly seemed to warrant the second are started by material particles brought through lymph-channels from an infected area to a node. The microbes which set up inflammation in vessels excite the same process in nodes, and almost always *lymphadenitis* (the technical name of the disease) is caused by extension of the lymphangitis of some tributary. When this is not the case the cause is usually to be sought in infection from a more or less distant point, the poison being conveyed to the node through vessels which may receive no harm from the toxic agent to which they give passage. Nodes are very prone to take on inflammation, and this generally spreads to the areolar tissue in which they are imbedded.

As acute inflammation of lymphatic nodes usually differs from the chronic form in etiology, course, and indications for treatment, the two will be considered separately.

Acute Lymphadenitis.—A previously unnoticed node displays the classical signs of inflammation. The pain is not great if the adjacent parts are kept entirely quiet, and there may be absence of fever. If the inflammation is not checked, suppuration occurs. The node and the skin covering it soften, and when a cluster of nodes is concerned they may form a single abscess by confluence. Evacuation of the pus is succeeded by rapid healing, but in depraved conditions of the system an ulcer, or even a sinus, may remain and be unresponsive to treatment for a long time. Rarely acute inflammation terminates in the *chronic form* or in *fibrous induration*, *caseation*, *calcification*, or *gangrene*.

Generally acute lymphadenitis is caused by the introduction to the node of some *irritant material* brought by lymphatic vessels. The principal pathological change observed is a vast increase in the number of cells, which block up the channels, and thus make the node more than ever a catch-basin for particles floating in the current of lymph.

TREATMENT must be prompt and active if the integrity of the node is to be saved. First, remove the cause if possible, seeking it at the periphery of the tributary vessels. Keep the inflamed part perfectly still. Reduce congestion by leeching or apply freely several times a day equal parts of carbolic acid and glycerin, or inject carbolic acid. The

last method has won much favor. Its value seems to depend less upon the strength of the acid than on the exact manner of its employment. Some surgeons use a 2 per cent. solution, others the liquefied acid, but all recommend the injection of all parts of the node. The needle of a hypodermic syringe is thrust nearly through the node lengthwise; it is then slowly withdrawn, and the acid is deposited all along its track—perhaps thirty minims if a weak solution is used, three or four if the strongest. Then firm pressure is applied. None of these measures are efficacious after pus has formed. When this stage is reached *incision* must be resorted to. If there are fibrous bands or adherent pus, curette the cavity, swab it out with a strong antiseptic, and pack it with gauze. When granulation has well begun healing may be expedited by a deep suture. The routine treatment of inflamed nodes with tincture of iodine is most undesirable. Iodine in any form probably does no good in acute lymphadenitis.

Constitutional treatment, although of secondary importance, may be needed, and the careful practitioner will not forget the possibility.

It is probable that a node is never thoroughly restored after having been inflamed. Its stroma is increased, it remains harder than is normal, and it has contracted adhesions to circumjacent parts.

Chronic Lymphadenitis.—Before entering upon the consideration of this form of inflammation of lymph-nodes it is desirable to devote a little attention to the subject of *scrofula*, to which, in the minds of non-medical people, and also of a not inconsiderable part of the profession, this affection is due in a majority of cases.

To deny the right of scrofula to a place in the nosology would until very recent years have been regarded as rank heresy. But my contention goes even farther than this, and challenges the propriety of considering scrofula as a demonstrable condition or even a tendency. Many years ago the domain of scrofula was undisputed even over diseases which to the wider pathological information of to-day are so absurdly dissimilar, and so wholly unlike the morbid exhibitions which we have been accustomed to hear called scrofulous, that their inclusion under this head is amazing and grotesque. Think, for example, of placing in this category cancer, hereditary syphilis, chronic hydrocephalus, diabetes, rickets, intestinal worms, and lice! and yet all of them have been reckoned as forms of scrofula. In our times, however, we hardly hear of scrofula except in bones and joints and lymph-nodes, the last by far the most frequently. The question arises with great pertinency, Are not all of these affections displays of tuberculosis? Certainly the pathologists do not hesitate to answer affirmatively as regards the skeletal structures and almost all of the lymph-nodes, which have hitherto been considered scrofulous. The only doubt in the well-informed attaches to the condition of a minority of diseased nodes, in which *neither tubercles nor the bacilli tuberculosis* are found. These nodes, clinically, are in no manner distinguishable from those which are emphatically tuberculous, and often are directly contiguous with them. But, considering that tubercle requires a period of time for its developmental and another for its degeneration changes, and that in both of these, and especially in the latter, the typical form is often wanting; and considering further that bacilli are not invariably detected in cases where we are positive that they must at some time have been, it seems not unreasonable to take these comparatively few cases out of their classic field and place them in that of tuberculosis. When this is done the province of scrofula is absolutely emptied. To be sure, the dictionaries still call it a tendency existing in some constitutions, but it is difficult to understand in what way this tendency is to be proved short of a pathologic demonstration, and when this is done there is no call to speak of a tendency, for there is an actual disease. The rational conclusion is that the term "scrofula" should be discarded as no longer useful. In a few years more it will not be necessary for a writer on lymphatic diseases to explain why he omits a description of scrofula.

Chronic lymphadenitis may be, though it rarely is, a sequel of an acute inflammation. Almost always it originates in the entrance of bacteria from the peripheral area drained by the affected node. These directly or indirectly excite inflammation of so low a grade that it often seems to have qualities which entitle it to be regarded as chronic from the outset. So deliberate is this process that it may consume many years before it runs its entire course, including its sequels. Its most characteristic feature is perverted growth of the connective tissues, which so hypertrophy as to destroy or crowd out the cellular elements and sometimes reduce the node to the condition of a fibrous lump. At other times the node attains a great size, in which case large cells are found to have developed. Many nodes in a locality are apt to be diseased at the same time, and often coalesce into hard, lobulated masses, which are always disfiguring, frequently cause suffering, and occasionally interference with important functions by pressure upon nerves, vessels, and other organs. These nodes, which are almost always the seat of *tuberculosis*, undergo the degenerative changes incident to that disease, and with especial frequency *caseation*. The cluster of nodes is converted into a cheesy mass, which may long remain unaltered or rapidly soften and be partly discharged, the remainder acting like a foreign body and maintaining suppuration. When spontaneous healing takes place the resulting scar is large, puckered, and unsightly.

Chronic lymphadenitis is most common in the poorly nourished, especially those of tuberculous or syphilitic parentage. It is very insidious in its approach, and the fact that a node is in trouble may not be suspected until an abnormal bulging is noticed on some part of the patient's neck—the favorite locality of the disease, because the mucous surfaces of mouth, nose, and ear offer so much more extensive opportunities for the admission of septic germs than are available for the inguinal and axillary nodes. There is no pain, as a rule, and the growth may remain unaltered for a long period.

TREATMENT must be both constitutional and local, the former being much the more important. Hygienic measures are most to be depended on—abundance of pure air and nourishing, easily-digested food, clothing adapted to the seasons in turn, baths, suitable exercise, favorable climate.

Unhappily, however, the majority of cases occur among people to whom such prescriptions are a mockery, to whom the exact antipodes of these conditions have constituted the entire environment and the most urgent invitation to the disease with which they are afflicted. Penury establishes the physical state which favors the development of the malady and an insurmountable obstacle to the adoption of the necessary means for its removal. Only the opulent can command the best constitutional treatment. We are driven, therefore, in a large proportion of cases, to depend upon medicinal remedies, and these are principally in the directly supportive class—tonics and stimulants, as cod-liver oil, iron, and the alcoholics, the last to be used with extreme caution. Arsenic, mercury, and iodine, of course in minute doses and in forms which are easily tolerated, have often seemed to aid in the correction of the constitutional perversity.

Local treatment should vary according to circumstances. If the node is hard, some good may come from the application with gentle friction of some ointment containing iodine, iodoform, iodide of lead, or iodide of potassium. When this device causes soreness of the skin, its use

should be left off until the skin is restored, and then renewed. Pus should be given vent as soon as detected, and the incision would better be small. The cautery knife at a dull red heat is preferred by certain surgeons. One advantage of early opening is the probability of a less offensive scar than follows spontaneous evacuation of the pus.

With a view to the substitution of harmless cicatricial tissue in the place of the morbid deposit, the centre of the node may be injected with a caustic, as two minims of a 10 per cent. chloride-of-zinc solution once a week or so, or three minims of equal parts of carbolic acid and glycerin. Puncture with the thermo-cautery will sometimes answer the same purpose, causing induration of the entire node.

Particular caution should be observed in the local treatment of inguinal tumors, which are supposed to be chronically inflamed lymphatic nodes. In two patients I have found hernia which had been diagnosticated by the attending physician as lymphadenitis, and in one of these a small knuckle of intestine was gangrenous.

When the tumor causes suffering by compression of nerves or vessels, or menaces life by interference with breathing or deglutition, nobody hesitates to advise removal. But these cases are infrequent, and concerning a cutting operation in the majority of cases the highest surgical opinion is divided. Of course every one would be glad to rid his patient of a mass which is probably tubercular, for infection of the system from the degeneration of these nodes may occur in any given case, though it certainly is not common. If there is only slight mobility of the tumor, nobody can tell how extensive a dissection may be necessary to remove it; and perhaps more harm than good comes from taking only a part away, for experience shows that such interference often excites more rapidity of growth in the remainder. There is a lack of information relative to the results of extirpating operations: the reports of them have been made too soon to justify conclusions as to their value. It is probably a safe rule to ablate masses which are freely movable, in order to prevent extension to neighboring nodes. Such operations are not difficult, as a rule, but when the tumor is not freely movable the case is far different. Then it is generally best not to use the cutting edge of the knife after the nodes are reached, for the vessels and nerves, and especially the jugular vein, are often so displaced, stretched, and obscured that they are apt to be mistaken for fascial bands and wounded in consequence. The fingers and blunt instruments are the safest implements in these circumstances. Piecemeal removal is often most expeditious, and by far the best.

Hodgkin's Disease.

There are not many diseases which have been called at one time by as many different names as that which we are about to consider, and its current titles are herewith presented, not as an illustration of the fertility of terminological invention, but that the reader who has known this malady by any one of these appellations may be made aware of the subject of this section. Here are the names: *lymphadenoma, generalized lymphadenoma, lymphadenosis, lymphoma, adeno-lymphoma, malignant lymphoma, malignant multiple lymphoma, infective lymphoma, adenia, adenosis, progressive glandular hypertrophy, hyperplasia of lymph-nodes, lympho-sarcoma, multiple sarcoma, lymphatic anæmia, splenic anæmia, pseudo-leucocythæmia, pseudo-leukæmia.* Unfortunately, some of these are used to designate more than one disease, and their employment is, consequently, very confusing; and others, while

affecting to give pathological information, are really misleading. It has seemed wiser, therefore, in spite of well-grounded objections to eponyms, to call the affection by the name of the observant physician who first gave an account of it, until a concise and correct descriptive title can be agreed upon.

Hodgkin's disease is more frequently seen in the young, and especially males. Its first manifestation is the enlargement of some superficial nodes, generally in the cervical region. They are not painful or tender, do not adhere to the skin or to each other, and show no tendency to caseation or suppuration. The spleen is a little enlarged and the general vigor impaired. There is a suggestion of anæmia, but the only observable alteration in the blood is a slight diminution in the number of the colored corpuscles. The case can certainly be made out to be neither cancer nor tuberculosis, and arouses but little suspicion of sarcoma.

Fig. 220.

Hodgkin's disease (Park).

The *enlargement of the nodes progresses*—if slowly, the tumor is probably hard; if rapidly, soft. Those in the arm-pits and groins are affected next after the cervical, and other groups follow suit. The only suffering comes from debility and depression of spirits, which are constant, and from fever, which is frequent. The blood may lose three-quarters of its colored corpuscles, but the colorless are not diminished. The skin is pallid and waxy and the mucous membranes are blanched. Variations in appetite are observed from anorexia to voracity.

In a year or two *every node in the body is enlarged:* the neck has ceased to be a constricted part and bulges hideously; the axillæ are stuffed with tumors; the groins protrude and the lymphatic colonies in the great cavities are correspondingly affected. Pressure produces results which vary according to the organ involved, and is responsible for pain, paralysis, perverted respiratory action, and interference with digestion and circulation. Death is due to exhaustion.

Post-mortem examination shows no formation of pus, no caseation, no breaking down of any kind. The nodes composing each separate group have become fused, the lymphoid tissue between them having increased and banded them together. They display increased vascularity and hypertrophy of tissue, the cellular elements being overgrown in the soft masses and the fibrous in the hard. Small, irregular lumps of new lymphatic tissue are scattered abundantly throughout the spleen, and the lungs, liver, kidneys, stomach, and intestines may contain similar deposits.

This is the history, in brief, of a pronounced and clear case of Hodgkin's disease, but deviations from this type are not uncommon, and the

future may prove that some of the so-called varieties are really different diseases. The most confusing (alleged) variety is that in which there is not merely a relative but an actual *increase in the number of leucocytes* in the blood. The difficulty in interpreting this condition, so opposed to that which is usual, is at least diminished by observing that this multiplication of colorless corpuscles is coincident with that form of hypertrophy of the spleen in which there is not only the typical, characteristic overgrowth of the lymphatic elements, but also an augmentation of the pulp; and this change in the pulp is the cause of the leucocythæmia. Thus we have developing in the same patient Hodgkin's disease with its loss of colored corpuscles, and splenic leucocythæmia with its vicious gain of colorless corpuscles.

FIG. 221.

Hodgkin's disease (Park).

Occasionally there is no enlargement of the spleen. It would be interesting to know if the other viscera, which are usually affected in advanced stages, are equally exempt. Sometimes the disease begins in the deep nodes, and then an early diagnosis is wellnigh impossible.

DIAGNOSIS cannot be made until the appearance of enlargement of nodes. The principal differences between Hodgkin's disease and leucocythæmia (with which, as we have seen, it is at times associated) are, first, that in the former *anæmia* is not pronounced until *after the lymphatic hypertrophy*, but in the latter anæmia is the first thing noticed; second, in Hodgkin's disease the splenic enlargement is slight until that of the nodes is very great, but in *leucocythæmia* the *spleen* is the *first* organ to show increase in size.

There is little danger of confounding Hodgkin's disease with carcinoma, as the latter almost never starts in the nodes. Tuberculosis of the nodes is attended with slowness of growth, earliness of agglutination, and a marked tendency to degeneration and the formation of pus—none of which phenomena are seen in Hodgkin's disease. Some authors declare that it cannot be discriminated from sarcoma, but in Hodgkin's disease the enlargement is purely hyperplastic, "while such tumors only are to be regarded as sarcomatous which in type have nothing in common with the mother-tissue" (Winiwarter). The microscopic examination of a bit of the growth cut out for this purpose would easily determine this point.

The recent discovery that the blood-leucocytes are not of one kind, but of five or more varieties, may be the key which is to unlock some of the mysteries of this disease, which needs to be studied anew from the point of view of this addition to our knowledge.

In the TREATMENT of Hodgkin's disease almost all drugs which have been tried have proved to be worthless. *Arsenic* alone seems worth a trial, as some tumors have diminished during its administration and a number of complete cures have been reported. As large doses as can be borne without toxic effects should be given. The general strength must be upheld in every possible way.

Local treatment does not promise much, if any, more than medicinal. Injections, massage, inunctions, compression, and blistering have all been tried fruitlessly. The propriety of operation always comes up for discussion. If the diagnosis has been made early—when, for instance, only a single and accessible group of nodes is involved, the spleen apparently normal, and the anæmia slight—removal of the mass should be practised; for, while this procedure cannot be warranted to exempt the patient from extension of the disease, it is usually attended with little peril, and it gives him the chance of benefit possibly resulting from the extirpation of a tumor which if allowed to remain may cause infection of the entire system. In order to do any good the removal must be thorough. If the disease has become general, operation is not to be thought of, except for the removal of such masses as mechanically cause suffering or interference with vital processes; and always in such a case it should be plainly stated by the surgeon that nothing curative can be hoped for from the operation, but merely temporary palliation.

SARCOMA OF LYMPH-NODES.

Although the cases are very rare, it seems to be fairly settled that sarcoma may affect lymph-nodes as a primary affection.

The DIAGNOSIS is not always easy—in fact, may not be possible until the node has been removed and subjected to microscopic examination.

The TREATMENT is, of course, ablation.

CHAPTER XXXI.

SURGICAL INJURIES AND DISEASES OF THE VEINS.

BY JAMES M. HOLLOWAY, M. D.

ANATOMY AND PHYSIOLOGY.—The veins exceed the arteries in length, calibre, and number. Like the arteries, they are composed of three coats—an inner serous, a middle fibro-muscular, and an outer fibrous, these being closely connected by cellular tissue. The serous coat is continuous with the membrane that forms the capillary vessels and lines the arterioles and venules. The fibro-muscular middle coat endows the vessel-wall with feeble contractile force, and aids the outer coat in securing elasticity and resistance against sudden or prolonged blood-pressure.

Valves do not exist in all veins, being present for the most part in those requiring the support of the column of blood against gravity and the pressure on large vessels within the abdomen due to physiological and pathological changes or overgrowths occurring therein. These valves vary in number and location in the vessels—*e. g.* in the superficial veins of the lower extremities. Bennett,[1] during a series of observations made under his direction, discovered remarkable facts in this regard.

This will account for the pathological conditions to be noticed elsewhere. Further observations showed that the valves are sometimes either entirely absent or defective congenitally, causing hypertrophy of one or both of the lower extremities, and also rarely of the upper extremities.

The circulation of the blood in the veins is for the most part centrifugal, and is not, as a rule, influenced directly by the force of the heart. Nevertheless, the heart's action constitutes a powerful factor, aided by peripheral capillary circulation, endo- and exosmotic currents, and muscular action.

Owing to numerous small branches given off from the larger vessels, and connecting them with each other, the superficial and deep veins are constantly interchanging their contents, and thus modifying the blood-pressure to an extent sufficient to prevent over-distention under ordinary conditions. Along with the veins and in close connection with them are found either *nerve-trunks* (with the venæ comites) or *filaments of nerves* that penetrate the muscles and supply the contents of the cellular planes.

The intimate anatomical relation of the lymphatic system to the veins demands recognition when treating of surgical affections of these vessels.

HYPERÆMIA OF VEINS.

This condition is a consequence of trauma, not only of the walls of the vessel, but of the adjacent or surrounding tissues. Contusion, puncture, or laceration of a vein, if not treated preventively, will be more or less speedily followed by swelling, induration, plugging, discoloration, and decided tenderness. If circumscribed, the elevation of temperature will be strictly local, and not always appreciable except by a surface thermometer. The surgeon rarely encounters such a case, because of its seeming insignificance. When called he finds that the hyperæmia has

[1] *London Lancet*, 1889, p. 1073.

extended upward along the course of the vessel quite a distance from the site of the injury. The vein can be outlined by the swelling and discoloration, and the pain and fever indicate a constitutional disturbance. Hyperæmia of veins is a prominent feature in the clinical course of a *sprain* in which preventive measures have not been employed or have failed. All of the structures about the joint are more or less involved; there is a general discoloration of the skin, the hue determined by its natural pigment. The veins are usually, in such a case, outlined by their fulness and the darker arborescent streaks. After the hyperæmia has subsided the mottled skin oftentimes remains to indicate the effusion of blood and the enfeebled venous flow through these superficial vessels. Frequently clotting occurs during the active hyperæmic state, and the vein is obliterated, leaving indurated masses that are likely to be mistaken for lymph-nodes or fibrinous deposits. These phenomena, observable upon the superficial, occur as well in the deeper parts, and may be properly cited as one of the causes of nutritive disturbances, pathological degenerations, and the formation and growth of *neoplasms*.

The TREATMENT of hyperæmia of veins demands physiological rest, support by dry or wet, warm, hot, or cold compresses of cotton or wool, and the supporting effect of concentric compression by bandages. Anodyne and astringent lotions may be added to these when pain and tenderness exist. A lead lotion with opium, an evaporating or stimulating lotion—*e. g.* distilled extract of witch-hazel, tincture of arnica, or the balsam-apple in rectified spirits—may be substituted. Compression by cotton batting or wool and the bandage supports, eases and favors resolution and the return circulation.

PHLEBITIS.

Inflammation of Veins (*Sepsis*).—*Wounds* of veins are the most frequent direct cause of this condition. The *absorption of septic fluids* from contiguous structures that are septic is the common indirect cause. Oftentimes, in either case, the lymphatic system is considerably affected, so as to render it difficult to decide as to their causal relation. The walls of the veins become swollen and less resistant, the serous coat is congested, the valves are less mobile, and the blood clots readily from stasis and the admixture of septic fluids. The parts directly within the area of the septic state become boggy, discolored, and more or less tender, the pain being burning and lancinating. The tendency is toward the formation of diffuse collections of pus in the adjacent structures.

The constitutional disturbance is alarming; the asthenic state is present; all the essential signs of fever are manifest; the pulse soon becomes feebler and less regular than in the sthenic fevers; the respiration is sighing; the skin is frequently bathed in profuse sweats; the countenance expresses concern; and the secretions from the intestinal tract and the kidneys are scanty. There is a general sepsis that may terminate more or less speedily in death by asthenia or by the formation of septic abscesses in the lungs or liver or brain. On the other hand, the patient may recover by elimination of the septic matter through intestinal drainage and free diuresis and diaphoresis, or by the formation of conservative dépôts of pus in the cellular planes.

TREATMENT OF PHLEBITIS (*Sepsis*).—The preventive treatment should be the aim of the surgeon—viz. when possible remove all foreign substances, blood-clots, etc. that will act as local irritants, establish and maintain free drainage, and employ aseptics and antiseptics. The technique will be suggested by each individual case. Should, however, these precautions have been neglected or have failed because of incompleteness in their application, no time should be lost in the thorough removal of the cause when practicable, and in the employment of constitutional treatment to lessen the gravity of the sepsis, and at the same time sustain the patient against the asthenic state so likely to prove fatal. *Free incisions* where the parts are boggy and tense, irrigation with sterilized carbolized water, the bichloride solution; after, drains of gauze or tubing, dusting with iodoform and boric acid, and over all aseptic and antiseptic gauze, the object being to prevent those putrefactive changes that result in the production of ptomaïnes and toxins. These for the local condition. For the constitutional state, already present, free drainage by the intestinal tract and kidneys is to be secured by small doses of calomel repeated at intervals of a half hour or hour, to be followed by small doses of Rochelle or Epsom salts until free purgation and diuresis occur. At the same time milk, broth, eggs, and wine or whiskey should be judiciously administered. Special attention should be given in such cases to the administration of from one-thirtieth to one-twentieth of a grain of strychnine hypodermically every four or six hours, to which may be added, when required, digitalin and nitroglycerin.

In cases of recovery the area of the local septic state is recognized by a persistent swelling and induration, upon the subsidence of which, under appropriate treatment by bandages, massage, and the hot and cold shower, the superficial veins may be outlined by irregularity and cordiness.

VARICOSE VEINS (VARICES).

There is no doubt about the dilatation of the *calibre* of the veins that are in a varicose condition. Nevertheless, veins that are dilated are not necessarily varicose. A difference between varicose and dilated veins is therefore recognized. This consists in the condition of the *valves*. In the former (*varix*) the valves are insufficient; in the latter (*dilatation*) they are not. In the former the walls are irregularly thinned, lengthened, and tortuous; in the latter the walls are more or less thickened.

A notable example of this is observed in *varicocele* that is present on the left side in fully 10 per cent. of adults. Here the veins are valveless, and when rolled between the fingers and thumb or compressed, furnish the well-recognized sensation of a bag of fishing worms. When excised for the radical cure of varicocele the walls are always found uniformly and sometimes enormously thickened.

Insufficiency of the valves is caused by a stretching of the wall of the veins so as to separate the thin free edges, leaving an interspace that permits of regurgitation of the blood in a direction opposite to the normal current. In consequence the column of blood has no longer support against gravity, and does not flow normally into collateral channels when interrupted in its more direct course. This valvular insufficiency

is a potent factor in progressively thinning the vein-walls and adjacent skin, and increasing the danger of their rupture subcutaneously or through the attenuated overlying skin or mucous membrane. Short of this, the pressure-effects of varicosities are liquid or semi-solid *œdema*; *pain* due (1) to the sense of fulness where stasis (congestion) results; (2) to pressure upon filaments of nerves or nerve-trunks; (3) to disturbances of nutrition, causing eczema, ulceration, overgrowth, more or less permanent *pigmentation*, the formation of *thrombi* and their degeneration into *phleboliths*.

Causation of Varicose Veins of Lower Extremities.—(1) *Thrombus* of large veins following an attack of typhoid or other long-continued fever; (2) *injury* of pelvis or thigh or leg, lessening nutritive powers; (3) *local pressure* of pelvic or abdominal tumors or fecal accumulations (the latter affecting the left limb); (4) *long-standing occupation*, affecting the long superficial internal saphena; (5) *congenital defect* in the arrangement of the valves, as noticed in the paragraph on the Anatomy and Physiology of the Veins, as recorded by Bennett.

Fig. 222.

Congenital varices (Park).

Constipation and pregnancy, especially the latter, aggravate the varicosity, the former being questionable as an exciting or aggravating cause. Occupation is not usually an exciting cause, but persons who are compelled to maintain the erect posture during long watches, during great heat, or are subject to frequent slight injuries have a tendency to varicosity very much aggravated. Age is not a determining cause, for in many instances the presence of varicosities is not discovered until far advanced. The disease is rarely noticed in persons under twenty-one years unless abdominal obstruction exists—a very rare occurrence. The tendency to the affection increases under certain limitations after adult life, and is much more common in old age in both sexes.

It is important to emphasize the statement that a deficiency in the arrangement of the valves and their integrity accounts for the presence or absence of varicose veins in persons of similar occupations, and in one or the other leg of the same person, whether male or female.

The complications of varicose veins of the lower extremities, as given by Bennett,[1] are *hemorrhoids, varicocele, varix over pubes, labial varix* in female, *ulceration* and *eczema*, persistent solid *œdema* (lymphœdema), *recent thrombus, old thrombus, valgus.*

Except pregnancy as a cause, more men suffer from varicose veins of the lower extremities than women. Simultaneously the deeper and superficial veins are often affected, while the superficial veins alone are often involved. When the deeper veins escape, pain is not a prominent feature, only a feeling of fulness and heaviness.

[1] *London Lancet*, 1889, p. 1074.

Varicose veins of *upper extremities* are caused by occupations requiring *over-use*—washerwomen who work daily and use their hands instead of wringers; men who work at brick-kilns pitching the brick in the erect position, and, after burning, loading wagons; tennis- and base-ball-players can be named.

The early symptoms are pain in a muscle or group of muscles in unusual localities of the arm, usually attributed to sprain. To diagnose such a case slight compression with a bandage around the arm near the axilla will speedily bring to view conspicuous varicosity. To prove the correctness of the opinion, apply a roller bandage and the movements will be made without pain; afterward direct the patient to wear an appropriate elastic stocking.

In extreme cases the same TREATMENT may be resorted to as is applicable to veins of the lower extremities.

Symptoms of Varicose Veins of Lower Extremities.—Incipient.—Crampy pains upon rising, passing off, and late in the afternoon a sense of fulness and heaviness, with more or less dull pain in one or both legs. Inspection rarely reveals varicosity of the superficial vessels, except perhaps a few slight varicosities near the saphenous opening, upon the outside of the thigh, in the popliteal space, on the fibular side of the leg, or behind the ankles. These may be altogether absent. In some cases slight œdema of the foot or ankle comes on later in the evening, enough only to be noticed because a loose shoe then feels too tight.

When the patient applies for relief during the early stage of the affection, it must be differentiated from gout or rheumatism. Later on, even if the patient has been properly advised, the superficial veins become enlarged and can be readily outlined. Then the diagnosis is easy. But in the latter stage the crampy pains upon rising no longer give trouble, and another train of symptoms appears. *Heaviness and fulness* of the limb are present in all positions except the recumbent. In some the sitting or standing posture causes greater pain, including a restlessness that forces the patient to move about. For a while the muscular effort causes the blood in the veins to flow more freely and relieves the pressure, but fatigue increases the pain again, and relief is only obtained by elevating the limb or lying down.

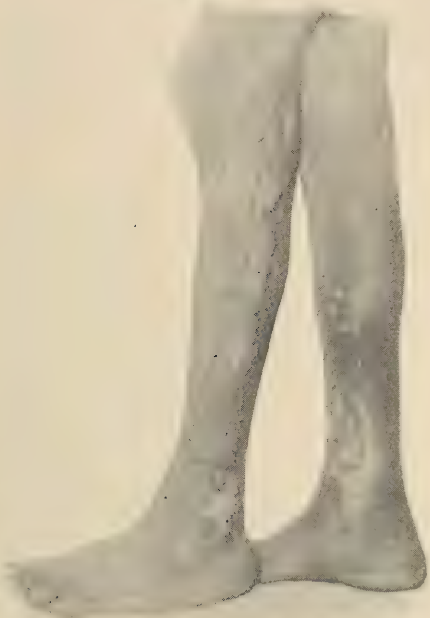
In many cases of extreme varicosities of the lower extremities observed in hospital practice the writer has called attention of students to the singular fact that the patients denied having any pain except a sense of fulness. Numbers of these have been members of the street-cleaning gang in this city for over twenty years; they have very large tortuous veins, eczema, serous or lymph-œdema, and some have ulcers. All of them remember the pain formerly experienced. In such cases the writer has taught that the pain is due to pressure usually of the enlarged deeper-seated vessels (comites) upon the nerve-trunks. He acknowledges, however, that the significance of the varicosity of the deeper veins was not fully appreciated nor understood until after a careful study of Bennett's[1] lectures on this subject.

Varicosities of the *deeper veins* are more commonly recognized now than formerly. When elderly laborers or women who are multiparous are able to pursue their usual vocations without much pain, the inference is warranted that their varicosities are confined largely to the superficial veins. Pain in the vicinity of superficial varices is commonly due to pressure upon filaments of nerves, not to any disturbance of the main branches. The sense of fulness and heaviness that is experienced is due to the general stasis in the foot and leg. The eczema and itching

[1] *London Lancet*, loc. cit.

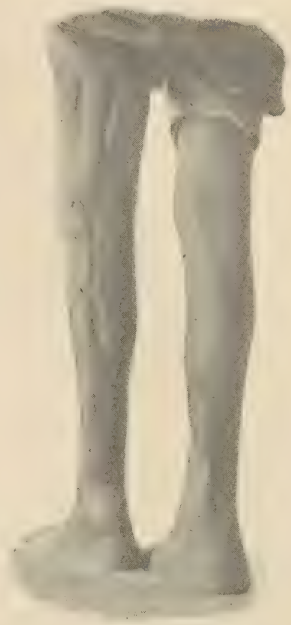
are due to the effusion disturbing the function of innervation in the sensory branches distributed to the skin. The ulceration and resultant ulcer are due to the *bursting* of a vein, to the *wound* of the cuticle by the

FIG. 223.



Varicose ulcers.

FIG. 224.



Varicose ulcers (original).

finger-nails employed to allay or modify the itching after lying down, to an accidental contusion or abrasion, to the presence of a phlebolith that causes molecular death by pressure or by becoming septic.

TREATMENT OF VARICOSE VEINS OF THE LOWER EXTREMITIES. —*Support* by the perfect elastic stocking or by the roller bandage is sufficient to ease the crampy pains upon rising and prevent the heaviness and fulness and slight œdema of the early or incipient stage. More radical treatment should be resorted to after the condition has advanced. *Multiple ligation* of the prominent veins, either subcutaneously or through incisions in the overlying skin, has proven effectual in many instances. But under the present aseptic and antiseptic method nothing short of *excision* of the internal *saphena* and prominent tortuous groups of veins below the knee can be recommended.

The writer has been afforded recent opportunities for testing the value of this method, and can highly recommend it. The operations were done in hospital and private practice, upon males and females between the ages of twenty-five and twenty-six years.

The technique, simple but tedious, is as follows: While the patient is standing encircle the upper third of the thigh by a rubber cord, tight enough to obstruct the venous flow, but short of compressing the artery. While an anæsthetic is being administered, the internal saphena and

veins below the knee, that were not easily outlined before, now become prominent. As soon as the parts have been thoroughly cleansed and protected by sterilized towels, an incision through the skin, six or eight inches long, should be made parallel to the internal saphena, but not directly over it. This precaution is taken to avoid wounding the vessel by misdirected pressure upon a blade of uncertain keenness. When the incision through the skin has exposed the subcutaneous cellular tissue, the knife must be laid aside or its handle only employed. With it and the fingers the vein and its variable number of branches must be teased out of their bed, and so thoroughly exposed that each branch and the proximal and distal end of the main vessel can be ligated.

Thus far, only chromicized catgut has been employed. It is much less easily handled than silk or kangaroo tendon, but has been sufficiently firm before its absorption to effectually close the vessels. An expert assistant aids greatly in the dextrous performance of the operation, for the curled condition of the dry catgut forms quite an obstacle to the facile threading of the blunt curved needle employed in the ligation, and wetting of the ligature by the oozing renders it so slippery that the compression forceps are needed to tighten the knot.

After the vessels have been secured they are excised by the scissors. Then, after cleansing the parts by wiping, not by irrigation, the edges of the skin-wound should be accurately coapted by silkworm-gut or catgut sutures.

Occasionally the undue pressure of silkworm gut will cause necrosis along its track and defeat a perfect union. As a rule, it answers and is sufficient, but the chromicized catgut is recommended, and if buried will, in from seven to ten days, leave the parts entirely free from foreign substances and firmly united. After the internal saphena has been disposed of, it is covered with an aseptic binder, and the large varices below the knee are excised or left untouched according to the judgment of the operator. It is safer for the success of the operation, however, if the more prominent ones are removed, unless there is a varicose ulcer or an extensive eczema, especially that form of the latter usually called weeping eczema, in which the desiccation of the exuded serum leaves large crusts: under such conditions it is difficult to maintain strict asepsis and antisepsis.

After the wound or wounds have been closed dust freely with iodoform or a mixture of iodoform and boric acid (1 part to 3), and cover with sterilized iodoform or borated gauze; then carefully bandage the entire limb firmly and evenly. The patient should be required to remain in bed ten days with the limb slightly elevated. Careful attention to regimen should be enjoined. Unless the temperature rises to the fever-point or pain occurs in the limb or at the site of the wounds, the dressing should not be removed until it is necessary to cut the coapting stitches. If catgut has been employed exclusively, the wound-dressing need not be examined for ten days. The limb should be carefully bandaged for a month or six weeks after the patient leaves the bed.

Under extraordinary circumstances, not likely to occur often, ligation of the femoral vein or one or more of the venæ comites of the leg is suggested when the method named above has failed to cure the varicosity. When the disability can be clearly attributed to a varicose state of the deeper veins and the subcutaneous veins are not plainly apparent, the writer would advise ligation of the deeper veins. Under the improved and constantly improving methods for doing thoroughly clean surgery this advice is deemed proper. It is given without hesitation since the experiments of Trzebicky and St. Karpinski in 1893 on the ligation of femoral veins.[1]

[1] *American Journal of the Medical Sciences*, vol. cvi. p. 606.

The operation of Schede has the same idea in view—cutting off the column of blood from above—but does it more effectually than any of the other methods. It is simply a circumcision of the entire leg at about the junction of the upper and middle thirds, dividing the skin and subcutaneous tissues down to the deep fascia, tying the bleeding points, and then sewing up the incision.

TREATMENT OF VARICOSE ULCER.—*Palliative.*—The various methods commonly employed are intended to *arrest the ulcerative process* (first stage), or to *stimulate it in the stage of arrest* (second stage), or *conduct it* steadily *through the stage of repair* (third stage). These methods have been considered fully elsewhere. Whatever plan of treatment succeeds in aiding the ulcer to heal leaves the limb in such a condition, on account of the varicosity, as to render reopening of the ulcer or the formation of others, under very slight exciting causes, probable. Therefore the only radical method by which a cure may be effected is to first excise or obliterate the main trunks that are varicose. Then the most effective plan is thorough *curettage*, loosening the edges of the ulcer with the handle of a scalpel, and aseptic and antiseptic dressing with proper support. If so large a portion of skin has been destroyed as to prevent contraction, *skin-grafting* will hasten cicatrization.

In a case recently operated upon the writer excised six inches of the internal saphena from the middle third of the thigh, and at the same time curetted a weeping ulcer of the leg that nearly encircled the limb. At the time of the operation the affected limb was one-third larger than its fellow. The subsidence of the limb and rapidity of repair that followed were marvellous.

The *eczema and weeping* that cause so much itching and distress in such cases before operation for radical cure can be lessened, and sometimes be made to disappear temporarily, by elevation at night and skilful bandaging during the day, the parts having been dusted with boric acid, bismuth, iodol, aristol, iodoform, oxide of zinc, or admixtures of these in proper proportions.

The *globular varix* that occurs oftenest at or near the saphenous opening is not always a dilatation of the saphena. Bennett describes two kinds that are dilatations of smaller collateral vessels—viz. (1) the *subcutaneous*, that is the more globular in shape and, under the thinned skin, is darker; (2) the *subfascial*, that is flattened by the denser fascia lata, its color being less dark because of its depth. Neither kind can be emptied by pressure, rebounding when digital compression is withdrawn. When these give rise to pain by pressure upon minute filaments of nerves, removal is the proper treatment. A curvilinear incision half around the tumor will expose it readily, and in the subcutaneous variety will lessen the danger of cutting into the tumor.

Landerer's method of treating varicose veins has not been sufficiently employed in this country to determine its value. Its simplicity is conspicuous, and if successful, even as a palliative measure, deserves prompt recognition in dealing with a class of cases that are not to be operated upon for a radical cure because of old age, visceral degenerations, pregnancy, or those necessities of life demanding continuous occupation. It consists in the *pressure on the saphena* above or below the knee by a "parabolic spring carrying a cushion filled with glycerin or water," attached to a garter that fits so loosely as not to constrict the limb.

The inventor claims remarkable results by this method, an interesting review of which, by Dr. J. P. Warbasse, may be found in the *Annals of Surgery* (vol. xx., 1894).

The *pulsation of veins*, as in *exophthalmos*, is due to defective or disturbed innervation, improvement under effective treatment being followed by lessening of the pulsation or its disappearance. *Sudden occlusion of a large vein* by plugging or its gradual obliteration by pressure of an overgrowth causes rapid *œdema* (effusion) or more gradual lymphœdema.

An illustrative case of the former (as recorded by the Paris correspondent of the *London Lancet*, vol. i., 1894) was a sudden plugging of the superior vena cava. An instance of the latter was observed by the writer in a case of carcinoma of the axillary lymphatics after amputation of the breast. The entire upper extremity on the affected side became enormously enlarged, and so indurated that firm pressure with the fingers or bandage failed to produced pitting.

Rupture of varicose veins is sometimes attended by profuse hemorrhage, and death has resulted. It always causes alarm to the patient and those around. To *arrest* the bleeding, elevate the limb and apply pressure with the finger until a compress and bandage can be applied. The flow of blood is mainly from the distal end, but, it is asserted, the proximal end also bleeds.

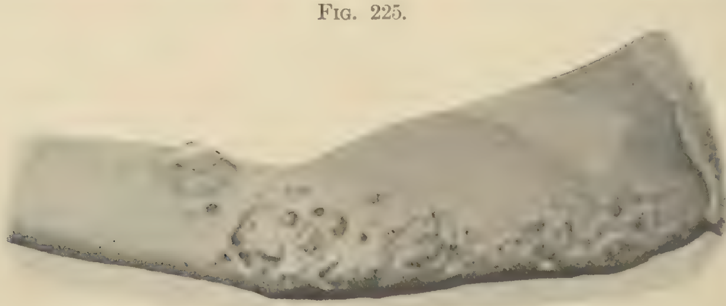
Venous Nævus.

This is one form of *erectile tumor*. It is usually congenital, but quite often acquired. It involves the skin and mucous membrane, and is found in the subcutaneous and submucous tissue. Nævi are discovered post-mortem in the liver and some other internal organs. They are situated more commonly on the head and face and in the cavities of the nose and mouth, pharynx, and nasopharyngeal space.

The writer has recently examined a well-defined venous nævus in the pharynx of a lady aged twenty-six years that had not attracted attention until about one month ago, when a hemorrhage led to its discovery.

The upper and lower lips, the tongue, the orbit, and the scalp are frequently the seat of the affection, and the dark *claret stains* or *port-*

Fig. 225.



Congenital venous nævus (original).

wine marks in the skin of the face and neck and upon the eyelid, usually called *mother's marks* or *birth-marks*, and attributed to maternal impres-

sions during intra-uterine life, are true venous nævi. They vary in size from the head of a pin to masses of relatively large size and diffused over large surfaces of skin, or form large tumors of divers shapes.

Fig. 225 represents a subcutaneous nævus of the arm of a young lady, who stated to the writer that it was congenital and had increased with the growth and development of the arm. Until examined carefully it resembled a mass of tortuous varicose veins. Some of these tumors pulsate; others do not. Some of them can be emptied by firm pressure; others are elastic, and the blood can only be displaced, owing to the thickness of the walls of the caverns and the amount of intervening hypertrophied connective tissue.

Certain forms of carcinoma and sarcoma resemble venous nævi in appearance, density, and anatomical arrangement, while distinct nævi form a part of such malignant growths. Many venous nævi (the smaller varieties) disappear spontaneously after birth, the blood-supply having been cut off; others increase in size, many of them outstripping the normal growth of the structures containing them. In some the growth is so rapid as to injure by pressure-effects, by closing more or less completely the cavities—*e. g.* obstructing one nasal cavity or lessening the calibre of the pharynx, thereby causing difficult deglutition.

Lennox Browne[1] reports *varices* of the *throat* and under the *tongue*, the former causing overgrowth of adenoid tissue and giving rise to tenesmus similar to that from piles in the rectum.

Turbinal nævi are likely to be mistaken for nasal polypi, from which they differ only in color and the absence of a pedicle. The deep-blue color of venous nævi when very superficial renders their diagnosis easy, but when erectile tumors are under the scalp or under thick skin or mucous membrane elsewhere, it is not always possible to decide whether they are venous or arterial. Especially is this the case when the tumor pulsates, and upon being easily emptied by pressure rapidly refills. From the capillary nævi of the skin, the diffused variety, the predominance of the special vessels dilated can be decided by the color. From cirsoid aneurism the distinction is made by the absence of a bruit and a pulsation synchronous with the heart.

TREATMENT OF VENOUS NÆVI (*vide* Chapter XXVI., Angeioma).—For the smaller circumscribed variety, that tends to disappear spontaneously, painting with collodion will so constrict the growth as to lessen its size and finally cut off the blood-supply. For the claret stains *tattooing* offers a method of cure that will reward the patient one. For the circumscribed increasing tumors on unexposed parts of the body and upon the scalp the *ligature*, inserted subcutaneously and made to transfix and surround the mass so as to cut off the blood-supply, will effect a cure without disfigurement.

The injection of *coagulating agents* is only named to be *condemned*. The writer was present many years ago when an unsightly nævus of the upper lip was injected with a solution of persulphate of iron. The tumor solidified with wonderful quickness, and then afforded favorable opportunity for excision and a subsequent plastic operation to restore the lip. This suggestion was disregarded, and the patient died ten days afterward from tetanus.

Excision offers a means for the cure of nævus, especially in those that do not pulsate and are situated under the skin. The bulbous *cau-*

[1] *London Lancet*, Jan., 1893, p. 177.

tery, after applying or injecting cocaine, is applicable to nævi on the tongue. The safest and least destructive method is *electrolysis*.

Marshall[1] presents this plan of treatment so graphically that it is copied here: "*Electrolysis.*—By its use we get (1) an operation which gives no after-pain; (2) it is free from danger; (3) there is no bleeding; (4) the scar is white, and does not tend to contraction in loose structures like the eyelids. In adopting this plan it is necessary at once to recognize the fact that it is not usually expeditious in its action: this is its chief drawback, because parents are apt to clamor for some obvious effect to be produced, and are loath to wait with patience for the gradual fading of the nævus, by which we get our best results. Occasionally nævi may be cured at one sitting without sloughing, and they may speedily diminish, but this is in my experience uncommon, and it is not wise to attempt to obtain so rapid an action, because the chances are against the effect being good. Stop the growth and be content to wait is the better method, reattacking if development takes place or its subsidence is long delayed. I always use the positive pole, with one or more needles according to the size of the growth and its situation. The needle (or needles, as the case may be) is moved about systematically to attack the growth in various parts. This is done without withdrawing the needle after it has remained long enough in one spot to produce some effect. It is wiser at first to work well away from the surface of the tumor, especially in raised nævi, which are very florid, to avoid risk of destroying the thin covering. The circuit is completed by attaching a rheophore to the negative pole: by this we avoid an unnecessary puncture, and I find that the process is equally effectual. I have not yet succeeded in finding a good means for insulating needles, and the scar left by the negative needles is brown and very disfiguring. I prefer to use the positive instead of the negative pole, because it is slower in its action, and therefore less likely to lead to sloughing, and the bleeding on withdrawal of the needle is much less troublesome. The objection to the scar left by the negative needle has already been referred to. The number of cells used, I find in my notes, varies somewhat, but my usual custom is to commence with five Leclanché cells, and increase according to the effect produced. Ten cells are generally sufficient, but in deep subcutaneous nævi I have applied twenty cells. The amount of tension caused must be carefully gauged, cutaneous nævi being capable of standing very little. Change in color to a dusky hue is a good guide to judge when it is requisite to stop the current. I arrived at the conclusions detailed here by testing the number of cells and their effect on nævi on the trunk, where scarring was of less importance. On withdrawal of the needle all that is required is, to rotate it before pulling, to free it, and then paint the orifice with collodion."

[1] *London Lancet*, 1889, p. 73.

CHAPTER XXXII.

SURGICAL INJURIES AND DISEASES OF THE ARTERIES, INCLUDING ANEURISM.

BY DUNCAN EVE, M. D.

STRUCTURE.—In considering the Surgical Diseases of the Arteries it will suffice to state, briefly, that their most important structural features consist of a thin inner coat composed of an epithelioid lining resting on an elastic base of no conspicuous thickness, *the intima*, continuous with the endocardium, the inner coat of the veins, and composing the entire coat of the capillaries; of a thick middle coat, *the media*, composed partly of muscular fibres disposed for the most part transversely, and partly of stout elastic elements, this being the thickest and most important of all three coats; and of an outer coat, *the extima*, consisting chiefly of elastic elements intermixed with an increasing amount of white connective tissue, this being the strongest and most dense of the three, the connective-tissue bundles being disposed for the most part longitudinally, and containing a number of connective-tissue corpuscles and a relatively large amount of elastic fibres. In many arteries bands of plain muscular fibres are present in this coat also, running for the most part, but not exclusively, in a longitudinal direction. Blood-vessels for the nourishment of the arterial tissues (*vasa vasorum*) are demonstrable in the larger arteries, being most abundant in the outer coat, but penetrating for some distance into the middle coat. Nerves, chiefly non-medullated fibres, may be traced through the outer coat into the middle coat, appearing to end in connection with the muscular fibres. Blood-vessels have not been demonstrated in the intima.

These features are possessed by all arteries. As a general rule, the muscular element bears a larger proportion to the elastic element in the smaller arteries, they being more conspicuously muscular and the larger arteries more elastic. The several arteries of the body differ, however, to some extent in minor features, such as the relative disposition and amount of muscular and elastic elements in the middle coat, the amount of muscular tissue in the outer coat, and the proportion of white connective tissue present; in the aorta a considerable quantity of white connective tissue is present in the middle, and even in the inner coat, as well as the outer coat. While all three coats, and especially the middle coat, contribute to give an artery its characteristic elastic properties, expanding under external pressure and contracting when the pressure is removed, it is the middle coat, which by means of its circularly-disposed muscular fibres, by their contraction, narrows and constricts, and by their relaxation permits the widening of, the vessels. The outer coat increases the tensile strength and resisting power of the vessel. The importance of the inner coat is centred in its epithelioid lining, smooth and offering but little if any obstacle to the onward flow of the blood, and being specially influenced thereby; the outer and middle coats deriving their nutrition from the vasa vasorum; and, possibly, the inner coat being entirely dependent on the current of blood flowing through it.

The arteries in their distribution are included in a loose areolar investment which separates them from the surrounding tissues and is called a sheath. Around the principal vessels this sheath is an important structure: it is composed of areolo-fibrous tissue, in which white connective tissue is far more abundant than the yellow elastic elements, the sheath being much less elastic than the artery, so that when an artery is cut completely across with its sheath, by elastic shrinking it contracts within the latter. The *sheath* is continuous with the fascia of the region in which the artery is situated, and from its blood-vessels are derived the vasa

vasorum; it also contains the accompanying veins, and sometimes a nerve. The sheath is absent in the cerebral and certain other visceral arteries.

The whole of the arteries proceed from a single trunk, the *aorta*, from which they are given off as branches, and divide and subdivide, usually dichotomously, to their ultimate ramifications. From the aorta the branches, for the most part, pass off at right angles, but in the limbs usually at an acute angle, and in some instances, as in the viscera and elsewhere, at an obtuse angle. In the division of an artery into its branches the combined area of the two is somewhat greater than that of the single trunk; and if the combined area of all the branches at the periphery of the circulation is compared with that of the aorta, it will be seen that the arterial blood is flowing through a conical space, with the apex at the aorta and the base at the periphery.

Communications between arteries are very free and numerous, and increase in frequency with the diminution of the size of the branches, so that through the medium of minute ramifications the entire body may be considered as one uninterrupted circle of inosculation or anastomosis. This increase of frequency of anastomosis with the smaller arteries counteracts their greater liability to impediments existing in, or obstructions developing within them, than in the larger vessels. Where freedom of circulation is of vital importance, as in the brain, this communication shown in the circle of Willis is remarkable, as it also is in the communication of the branches of the coronary arteries of the heart, being also quite a prominent feature in the alimentary canal, around joints, and in the hand and foot. Upon this free communication existing everywhere throughout the arterial system is based the curative principle of the ligation of the larger arteries: the ramifications of the branches given off above the ligature inosculate or anastomose with those proceeding from the trunk or its branches below, these communicating branches enlarging and forming a *collateral circulation*, first demonstrated in a series of beautiful preparations made by Sir Astley Cooper showing several large branches performing the duty of a single obliterated trunk. Under the stimulus of increased blood-pressure through the branches by the arrest of the flow of blood through the trunk a true hyperplasia of the various coats and hypertrophy of the branches result. Nothnagel and Recklinghausen explain the growth and increased development of the branches by the increased rapidity of the blood-current within them, and the increased amount of nutrition thus brought about. The more blood that passes through a vessel in a given time, the greater amount of nutritive material supplied to the wall of the vessel.

MALFORMATIONS AND MALPOSITIONS.

"Defects of development in the large arterial trunks" (Ziegler) "are of grave import." Thus, *e. g.*, *absence* or *imperfection of the septum* of the *aortic bulb*, the aorta and the pulmonary artery arising from a single stem, or *abnormal position* of the septum, the aorta being displaced to the right or in extreme cases arising from the right ventricle; *permanent patency* of the *ductus arteriosus*—a defect at one point being to a certain extent compensated for by an abnormality at another.

Simple atrophy of the walls of arteries is observed in connection with general marasmus and atrophy of individual organs. After amputation of a limb the arteries usually become smaller.

The principal arteries, those requiring correct surgical knowledge, as a general rule have definite and analogous positions and like relations in different individuals. Anomalies of position, course, and distribution are by no means infrequent, and are fully considered in special and general works on anatomy, want of space precluding their consideration here. This must ever be kept well in mind by the surgeon, as well as the possibility of the occlusion of original trunks by emboli, thromboses, previous surgical operations and injuries, and the development of collateral branches in the vicinity. L. Testut of Lyons,[1] in his monograph on mus-

[1] *Les Anomalies musculaires considerées au point de vue de la ligature des arteres*, O. Doin, Paris, 1893.

cular anomalies which are of importance to the surgeon, states that the large arteries which he has found to be occasionally covered by supernumerary muscular bands are the brachial, axillary, subclavian, internal mammary, popliteal, posterior tibial, and peroneal. He has met with no muscular anomalies which would affect the ligature of the carotids, radial, ulnar, iliacs, femoral, or anterior tibial, and has, consequently, left them out of consideration.

Thrombosis.

The circulation through the arteries being so active and energetic, a coagulation from stagnation is not likely to occur. A change in the inner wall of an artery is the commonest cause of thrombosis, but this is a matter of degree; and if the circulation remains vigorous, even a considerable change of surface will not necessarily produce coagulation. When the circulation is sluggish it is more apt to occur.

In *atheroma*, subsequently to be considered, calcareous plates are often found which, in some cases by absorption of the inner coat or its destruction or disappearance, come into contact with the blood-stream and result in a deposition of fibrin thereon. This is most frequently noticed in the aorta, but it may occur, though more rarely, in smaller arteries, and cause complete obstruction of them; the consequences of which in the arteries of the brain or heart are very important or even fatal. This process is with difficulty to be distinguished from embolism, which will subsequently claim attention.

Virchow attributed coagulation of blood in a living vessel to a slowing of the current, but it has been shown that blood may be kept stagnant in a vessel by two ligatures, and coagulation will not result if the vessel is kept aseptic and uninjured. Slowing of the current with these conditions accompanying will result in coagulation, as will in less degree injury to the wall of the vessel, roughness of its inner coat, introduction of a foreign body, or septic infection, without change in the current; yet if the retardation of the latter occurs, it is more certain. The blood-plaques or third corpuscles are important factors in the coagulation of circulating blood. With irritation, roughness of the intima, etc., with or without retarded current, the blood-plaques rapidly leave the current of the stream and accumulate at the point in question, and numbers of leucocytes are also arrested and become attached thereto, thus forming a viscous mass projecting from the wall into the lumen of the vessel, the fibrin of the blood having an affinity for the accumulation of blood-plaques and leucocytes, binding together the mass, in which may be entangled red corpuscles. A clot, once formed, has a tendency to enlarge by coagulating the blood in contact with it. Coagulation beginning at one side of a vessel may spread until the vessel is blocked.

Thrombi are spoken of as "(1) *parietal*, and (2) *obstructive*, according as they are attached to the wall of a vessel or occupy its whole lumen. The one kind may, of course, pass into the other, but the structure of those which are at first parietal is different from that of those which are formed by coagulation of the whole column in a vessel."

"1. *Parietal thrombi* are always formed of successive layers. The first layer (as Zahn has observed during life in the transparent part of frogs) is formed of leucocytes with a little fibrin; on this another layer is deposited, and so on. For some reason, not yet understood, the successive layers are often different in color, some consisting entirely of leucocytes and fibrin, others containing red corpuscles also, producing an appearance like the structure of an agate. This laminated structure is traceable to the last in such thrombi, and is often obvious to the naked eye—for instance, in the layers of clot inside an aneurism. Some parietal thrombi are almost wholly composed of fibrin and leucocytes, and are known as 'white thrombi.' Some layers may be transparent or

hyaline, but generally there is a large quantity of a finely granular substance known as molecular fibrin.

"2. *Obstructive thrombi*, consisting of the whole mass of the blood, will at first precisely resemble ordinary clots formed out of the body, but undergo certain changes.

"These changes are: In the first two or three days the thrombus becomes firmer and drier from loss of the serum squeezed out of it in contraction. Next it becomes somewhat adherent to the wall of the vessel. Later on the blood-pigment diffuses out of the corpuscles, and the whole clot becomes tinged of a reddish-brown color from altered hæmoglobin or hæmatoidin. This is, however, absorbed, and the clot becomes partly decolorized, especially in the central portions. The loss of color is good evidence of the age of the clot.

"What may be considered a natural or healthy end of this process is the so-called '*organization of the thrombus*.' It becomes gradually replaced by a mass of connective tissue, which either converts the vessel into a fibrous cord or else becomes channelled and allows it to become pervious again."[1]

It is an unsettled question as to whether the coagulum is an active or passive agent in this organization. The most satisfactory view is, that it becomes organized by young tissue growing into it from the vessel-walls, the vasa vasorum pushing their radicals on through the middle coat, beyond the intact, or more probably the injured or defective, intima, or its site, into the clot, developing connective or cicatricial tissue, disintegrating and absorbing the clot, in some instances leaving spaces in the newly-formed tissue, which has a spongy consistence, forming channels through which the blood may again circulate.

However, another transformation of the thrombus may occur, or what is known as softening. The fibrin and leucocytes disintegrate into a fatty mass, which forms a slimy fluid of pulpy or creamy consistency in the inner layers of the thrombus, and it is thus broken up. The microscope shows this to be granular matter with shrivelled and degenerated leucocytes. Rarely, the number of the cells is so great as to present an appearance very similar to pus, pus itself only developing under septic influences.

The *result of this softening* is, that (1) the softened matter may pass into the blood without injurious consequences, the only result being that the channel of the vessel is opened up; (2) a fragment may be carried on into some smaller vessel, which it will obstruct, forming an embolus; (3) the matter may contain *septic material* (pus), producing general disease or setting up suppuration or necrosis at the point where it becomes ultimately lodged. Fragments of thrombi may be detached by the force of the blood-stream, by movement or some mechanical accident without softening, and be carried off to be lodged elsewhere as an embolus.

Emboli may be formed from other substances than a blood-clot. When tissues containing fat are broken down by injury or disease, drops of fluid fat enter the circulation, and may be lodged in the branches of the pulmonary arteries and capillaries. Emboli are simple or mechanical and specific, the one producing only the effect of obstruction, the other general or localized septic infection. Simple obstruction

[1] *Manual of General Pathology*, John Frank Payne, M. D., 1888.

of an artery by an embolus is generally indicated by the suddenness of the symptoms, referred to the part beyond the obstruction. In most cases the obstruction is increased by the extension of a thrombus from the embolic mass. The column of blood both in front and behind the embolism is brought to a state of rest and coagulates. This also occurs in partial obstruction.

The embolus is most frequently arrested at the bifurcation of an artery, and secondary thrombi may extend into the branches. Vegetations carried away from the aortic valves, lodging in the middle cerebral artery, with or without subsequent thrombosis, suddenly developing hemiplegia, aphasia, and other symptoms showing a morbid condition of that part of the brain supplied by this arterial branch, constitute a by no means uncommon form of cerebral embolism. In the same condition of the aortic valves there may be sudden and painful obstruction of the femoral artery, the embolus lodging at the giving off of the profunda, the limb becoming cold, pulseless, and subsequently gangrenous.

"If the main artery of a limb be blocked," says Payne, "the anastomosis may be perfect enough to restore the circulation after a time, so that no permanent effects follow. If the anastomosis be insufficient, we get, in the external parts, gangrene."

If an artery going to an internal organ is blocked, there will in many cases be sufficient lateral anastomosis to restore the circulation; but if a terminal artery is occluded, the consequences are very apt to prove serious by reason of rapid necrosis (softening), slow necrosis (wasting), or a hemorrhagic infarction.

Emboli only move in the direction of the blood-current in the arteries.

The TREATMENT of thrombosis and embolism is mainly prophylactic. Their thorough consideration is of importance in the treatment of surgical diseases and the pathology of the arteries.[1] In some instances the production of a thrombus is essential. Care should be taken, however, in all cases that the thrombus does not give rise to embolism. The parts therefore should be kept perfectly at rest, with as slow and easy pulsation as possible, until organization or absorption of the thrombus occurs.

ARTERITIS.

Inflammation of arteries as a result of extension from the tissues adjacent is of common occurrence; however, they are more resisting than many other tissues; thus in hospital gangrene, now rarely seen, they are the last of the soft parts to yield to the destructive invasion, and have been often seen completely uncovered or lying loosely in a mass of necrotic and sloughing material, still serving the important purpose of carrying the vital fluid on to more distant parts. In malignant disease the walls of the arteries may be thickened even to the extent of occlusion by irritative hyperplasia, or blocked by clot, thus preventing serious hemorrhage in many instances as the process of erosion advances. It is yet an open question whether acute arteritis occurs as a primary affection. A few doubtful cases have been recorded in which severe pain and tenderness existed along the course of an artery, in some instances accompanied by a certain degree of redness and swelling. The diagnosis has been made, but, a favorable termination occurring, pathological proof demonstrating its existence is wanting.

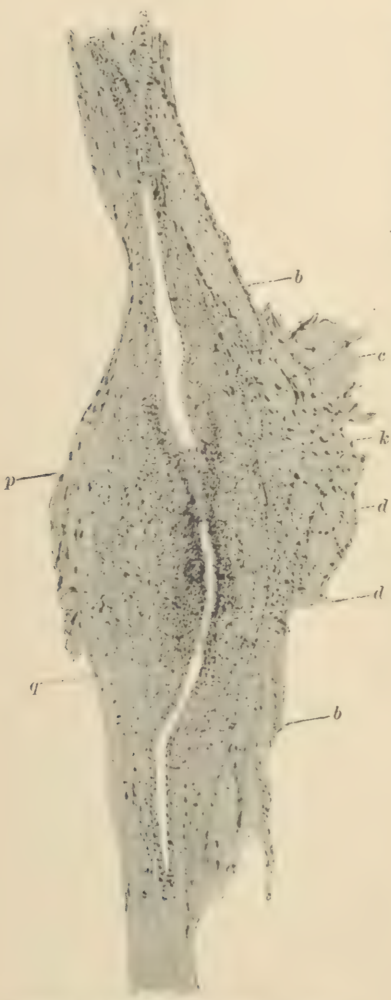
Each coat of an artery may be separately involved; thus we have *periarteritis*, *mesarteritis*, and *endarteritis*, these distinctions being more

[1] For more thorough consideration of the pathology of thrombosis and embolism see p. 32 *et seq.*, Chap. II., "Surgical Pathology of the Blood."

important in a pathological point of view than for curative treatment at the hands of the surgeon. Mesarteritis is generally an accompaniment of endarteritis, fibrous deposits taking the place of normal elements and muscular fibres as they gradually disappear in the middle coat. The changes rarely extend to the same degree in the intima, but here and there the normal tissue may be completely replaced by cicatricial or fibrous tissue. Periarteritis, usually secondary in character and due to extension from surrounding lesions, results in fibrous thickening and condensation of the outer coat. The thickening may be diffused or aggregated into coarse bands or nodes —*periarteritis nodosa* of Kussmaul and Maier—or destructive ulceration may occur. In destructive inflammation and ulceration of the arterial coats the lumen of the vessel is generally occluded by a thrombus before perforation occurs. Should thrombosis not develop, severe and sometimes fatal hemorrhage may arise if the artery be of sufficient size.

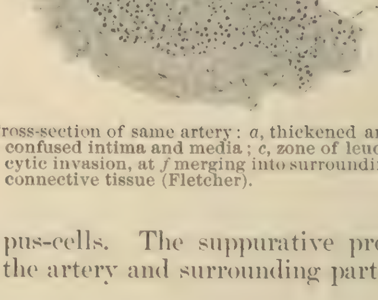
Acute arteritis is a rare surgical disease, and is due to infectious material or to toxic embolus lodged in the vessel. The internal coats

FIG. 226.



Arteritis and periarteritis nodosa; small artery from peritoneum: *b*, thin muscular layer; *c*, adventitia; *k*, thrombus (Fletcher).

FIG. 227.



Cross-section of same artery: *a*, thickened and confused intima and media; *c*, zone of leucocytic invasion, at *f* merging into surrounding connective tissue (Fletcher).

become swollen and infiltrated with pus-cells. The suppurative process may extend to the other coats of the artery and surrounding parts, and may result in abscess.

Syphilitic arteritis may occur, either as an independent disorder or as part of a local syphilitic affection. The intima and adventitia are

thickened by fibrous hyperplasia or diffused cellular infiltration. The media may be but little altered, or here and there atrophied and fibrous. The thickening of the coats may be so extensive as to almost or entirely occlude the lumen of the vessel.

Tuberculous inflammation is very common in arteries running through organs or tissues involved in tuberculous infiltration. Tubercles and diffused patches may appear in their walls, and if the granulomatous focus becomes caseous, the vessels undergo the same changes, rupturing or giving rise to hemorrhage, unless prevented by a previously formed thrombus.

External injuries of the soft parts may result in hyperæmia and congestion of the arterial coats, attended by throbbing pain along the course of the artery involved, subsequently subsiding or developing localized atheroma. Ziegler says: "*Purulent arteritis*, issuing in suppuration and destruction of the wall of an artery, is generally a secondary process occurring within suppurating wounds and ulcers. Inflammation and necrosis extend by continuity from the surrounding tissues to the vessel, destroying first the adventitia and then the other coats. The wall appears thick and yellowish or gray in color; the intima is turbid, yellowish or grayish, and infiltrated with pus. Often the brittle or rotten vessel gives way and hemorrhage follows. Secondary hemorrhage in wounds, hæmoptysis in phthisical lungs, hemorrhage from cancerous ulcerations, etc. are all of this nature; and in the same way fatal bleeding may occur from suppurative inflammation of the umbilical cord in infants. At times, as in tuberculosis, the necrotic process takes on a caseous character. Sometimes purulent arteritis with necrosis is due to the entrance of irritant matters into the blood, as happens in embolism when the emboli are virulent or infective. When the destructive process spreads from the vessel to the neighboring tissue abscesses are formed. The pus-corpuscles which in these processes accumulate in the substance of the vessel-wall are in part derived from the vasa vasorum, in part from surrounding vessels.

Fatty degeneration occurs in the inner coats of arteries, especially the aorta, carotids, and cerebral arteries, developing small, rounded or angular whitish spots, which are elevated slightly above the surface, the fatty changes first taking place in the connective-tissue corpuscles, and subsequently the intermediate substance softening, the masses of fat-granules falling apart and being carried away by the blood-current, leaving velvety-looking depressions.

Calcification, most frequently met with in the peripheral arteries, occurs chiefly in the middle coat, and consists of a deposit of earthy matters, mostly calcium phosphate, with a little carbonate, forming plates, rings, or tubes, known as *laminar*, *annular*, and *tubular* calcifications. The result is a deficient supply of blood, owing to a narrowing of the lumen of the vessel and want of contractility. When it is extensive enough to entirely occlude the vessel, gangrene may result. It is often readily detected in superficial arteries, as the radials, by the finger placed on the vessels, which feel hard, rigid, and unyielding. Calcification occurs chiefly in cases where the nutrition of the cell-wall is impaired and when degeneration of tissue has already taken place. It is a very common sequel of fatty change, and also of atheroma or sclerosis. The calcareous matter is deposited in the intima as well as the media. In the former it is mainly the atheromatous patches which become calcified, forming definite and cohering plates which may be removed entirely. When in the media the whole vessel may be converted into a hard and rigid tube, noticed most frequently in the larger and middle-sized arteries of the trunk and limbs, the inner surface often

having a ribbed or corrugated appearance, from which, if the intima is peeled off (which may be readily done), it is seen that the ridges spring from the middle coat, the intima being more or less atheromatous. The deposit of ossific matter in the arterial coats—ossification—occurs but rarely.

Atheroma, also known as arterio-sclerosis (chronic arteritis?), is a degeneration of the arteries, fatty and atheromatous, usually attended with thickening of the intima, later also of the media. It is a process common to age, when it is found attended with other evidences of senility, as the arcus senilis, atrophy of the kidneys, and general atrophy, and is an expression of involution.

The condition is developed in maturity and youth by errors and excesses in diet, alcohol, syphilis, rheumatism, and gout; hence the expression that has been used, that "a man is as old as his arteries." One-half or more of the cases of atheroma have been known to have been preceded or accompanied by rheumatism or gout, the former occupying by far the larger proportion of the two. It may occur in any condition which raises the pressure in the arterial system, as hard work, luxury, and a sedentary life. It arises also in cases of retention of toxic materials, as in diabetes, uræmia, and gout. It occurs more frequently in males than in females, in the old than in the young. Those vessels subjected to the greatest strain suffer first, as, in the order of frequency, the ascending aorta, its arch, the descending aorta, the splenic, iliac, and crural, the coronary, cerebral, uterine, brachial, radial, and ulnar arteries. The disease process shows itself first as simple thickening of the intima, and is followed by fatty degeneration, with the deposit of calcareous matter, often by subsequent ulceration and cicatrization. The first changes may be so slight as to be scarcely noticeable, but soon the internal surface becomes roughened and irregular, and opaque yellowish patches are seen here and there. The patches consist of a rapid proliferation and multiplication of the cells of the subendothelial tissues, which may become so numerous as to push the endothelial cells before them, encroaching upon the lumen of the vessel even to the point of obliteration; and the endothelial cells themselves are in many cases the seat of a true hyperplasia.

Atheroma occurs in two forms, *nodular* or *localized*—mostly seen in the aorta and larger vessels—and the *diffused*.

In the *nodular* form there are seen upon the inner lining of the artery grayish or yellowish elevations presenting an appearance not unlike cartilaginous plates, the edges either abrupt or gradually sloping. In size these sclerosed spots vary from small points to that of an inch or more in diameter, and may be so numerous as to thickly stud the intima. Later, degenerative changes or necrotic softening occurs within the plates, and they are then composed of soft, grumous, molecular material, developing into *atheromatous abscess*, which may rupture on the surface of the intima, discharging its contents, leaving an irregular necrotic area, the *atheromatous ulcer*, often covered with fibrinous deposits; the final change being calcification, which may occur in the base of the atheromatous ulcer or in the plates before rupture. *True ossification* has occasionally been observed. The media and adventitia may be thicker than normal, the former presenting more or less calcareous infiltration. In other instances, especially when localized dilatations of the vessel are present, the middle and outer coats are thinned and degenerated. Fibrinous thrombi are apt to form on the ulcerated surfaces.

The *diffused* form of atheroma is most often met with in the smaller arteries, being frequently seen in strongly-built, muscular men whose work has been laborious and who have been much exposed. The

arteries are thickened and dilated, and at the same time lengthened, so that they become more or less tortuous. The intima presents spots of a dull-white appearance, but not distinct nodules; and there may also be areas of degeneration. The subendothelial tissue is greatly thickened; and the muscle-fibres in the media variously degenerated, sometimes distinctly fatty or necrotic, at other times converted into hyaline material, all resemblance to muscular tissue being lost. The adventitia is thickened and dense.

Taking the well-known etiological factors of atheroma, dissipation, excesses, errors in diet, rheumatism, gout, syphilis, etc. and toxic conditions of the blood, thereby interfering with perfect nutrition of the intima, developing excessive and possibly defective cell-proliferation of the subendothelial tissue, and imperfect development of the endothelial cells, are of paramount consideration. Laborious work, excessive muscular effort, with or without exposure, increasing the cardiac force, also interfere with the proper nutrition of the intima. Strain is very generally accepted as a sufficient cause for the production of changes in the vessels, whether it results from the repeated and sudden increase of blood-pressure incident to excessive muscular effort, or from the repeated overfilling of the blood-vessels, due to excessive alimentation of the *bon vivant*. Mental strain and anxiety may also have a like influence.

Contusions and external injuries, having a temporary influence upon the intima of an artery, which may be perpetuated to the development of local atheroma from traumatism, the hyperæmia, instead of subsiding, may so interfere with the nutrition and development of the endothelial cells as to result in atheroma.

Hypertrophy of the heart, which so uniformly results from atheroma, occurring independently of this condition, driving the blood on more forcibly, may so interfere with normal nutrition of the intima at certain localities as to be a causative factor.

Alanus observed sclerosis of the temporal and radial arteries in a young man under forty years of age, temperate, but a vegetarian. Raymond saw it in a number of young monks, vegetarians; and Treille remarked it of the inhabitants of Bombay and Calcutta, who live largely if not exclusively on rice. According to Galen, "vegetable food injures the blood-vessels and precipitates the changes of age."

In the early stages of atheroma, when the elasticity of the aorta and other arteries has been impaired by degeneration of the media and adventitia, there is increased demand upon the heart, and in consequence hypertrophy is commonly present. The weakened arteries are prone to undergo dilatation, with formation of aneurism. Thoma limited this period to about a week's duration, this being the date preceding the compensatory thickening of the intima; after which aneurisms are less likely to be developed.

SYMPTOMATOLOGY.—*Degenerative changes* may be shown in autopsy which were unsuspected during life, owing to the mildness or indefiniteness of the symptoms. So few of the arteries involved are within reach of tactile investigation, and early diagnosis is of such importance, that it is necessary to carefully consider even slight changes in any clinical phenomena in order to arrive at a correct conclusion. We may first find indications from the pulse: its tension may be high, although the hardening of the artery may amount to nothing, but sometimes we find the one accompanying the other, the radial being felt as a hard, rigid cord, which can be traced up the arm to the brachial and axillary. The pulse-wave is rather slow from want of elasticity of the vessel, the sphygmograph showing a short up-stroke with broad summit, and slow, gradual descent. The loss of elasticity and increased blood-pressure may also be indicated by the tortuous character of the temporals, and sometimes by the radial and brachial.

Hypertrophy of the left ventricle is early manifested by increased area

of cardiac dulness and augmented force of the systolic sound. The second sound of the heart heard over the root of the aorta is decidedly accentuated and ringing—a natural result from increased arterial pressure, or, more properly, resistance. Dilatation may follow hypertrophy with its usual train of symptoms.

The detection of atheroma at the wrist is not positive information as to its existence elsewhere, and autopsy will sometimes show serious lesions of internal arteries when those more superficial are normal; yet we may usually look for arterial lesions when we find obvious changes at accessible points.

One of the most important regions affected is the brain, indicated by headache, vertigo, or syncopal seizures, or cerebral hemorrhage due to the rupture of an atheromatous vessel or miliary aneurism, or embolism or thrombosis followed by impairment of memory, weakness of intellect, etc., due to cerebral softening. When the cerebral vessels are involved an interesting diagnostic point is an ophthalmoscopic examination, which shows pulsation of the retinal vessels, dilated veins, and whitish spots of degeneration of the retina.

Kidney-changes are common, and may follow or precede the arterial lesion. The symptoms of contracted kidney—urine increased, diminished specific gravity, a small amount of albumen with hyaline casts—may be found.

Treatment.—It is generally accepted that organic changes in the arteries, as elsewhere, offer but little if any promise as regards curative treatment. However, Bartholow, with others, has claimed that the double chloride of gold and sodium has the power of absorbing connective-tissue growth, and hence is useful in arterio-sclerosis. Others have claimed benefit from iodide of potassium, whether due to syphilitic lesion or otherwise. Billings claims that Basham's mixture, or tr. ferri alone or with dilute phosphoric acid and glycerin, has given good results; with Huchard he also places stress upon milk as a diet.

Prophylactic measures and means to stay further invasion are of greater importance. Of the utmost necessity is the avoidance of those diseases, habits, and customs which have been known to be productive of this condition. A quiet, well-ordered life, free from mental and bodily strain, avoidance of excesses in eating and drinking, as well as excesses in muscular exertion, are essential, together with good hygienic surroundings and a sufficiency of sleep at regular hours. *Complete attention to the eliminatory organs*, clean and freely-acting skin, and proper work on the part of the kidneys and bowels must not be lost sight of, and the patient should be thoroughly instructed as to the details of his daily life. If the heart's action should seem to be excessive as a result of high arterial tension, it may be modified by a cautious use of the nitrites, amyl, nitro-glycerin, etc. Bleeding may prove beneficial in some instances. When the heart's power shows indication of failure cardiac stimulants may be resorted to, but with the utmost caution for fear of rupture of the cerebral or other weakened vessels.

Aneurism.

An aneurism is a tumor filled with blood and communicating with the lumen of an artery. With this general definition we have several material modifications.

A true aneurism is one in which the walls of the sac are formed by the coats of the vessel, of which one at least is intact. It may be *saccular*, *sacculated*, or *sacciform*, consisting of a pouch projecting from one side of the vessel and communicating by a small or large opening with the latter. It may rupture and become *diffused*. A *hernial aneurism* is one in which the inner coat or the inner and middle coats are projected through the outer coat; it may be sacculated or may rupture and become diffused. A *cylindroid*, *tubular*, or *fusiform* aneurism is formed

by a uniform dilatation and growth involving the whole circumference of an artery; it may rupture and become sacculated or diffused. A *dissecting* aneurism is one making its way between the coats of the artery; it may be sacculated, may rupture, and be a diffused or false aneurism, and yet again become circumscribed. A *traumatic* aneurism is one produced by a wound, traumatism, or injury of an artery from within or without, and may be diffused or circumscribed; or *arterio-venous*, constituting *aneurismal varix*, in which the blood is poured into an adjoining vein; or a *varicose aneurism*, through an intervening aneurismal sac, and then into the vein. Nearly all traumatic aneurisms and all diffused aneurisms are false aneurisms, having no arterial coat around them. *Arterial varix* is a single dilated and tortuous condition of smaller arterial vessels and capillaries.

Aneurisms are thus, from an etiological standpoint, divided into *traumatic and spontaneous or endogenous.*

External aneurisms include those outside the visceral cavities, and are named from the vessel affected, as *carotid, popliteal, etc.;* and **internal aneurisms** are designated by the cavity in which they occur, as *thoracic*, those of the thoracic aorta and its branches, including *cardiac* aneurism, a partial sacculated dilatation of the heart; *abdominal*, of the abdominal aorta and its branches; *pelvic* and *intracranial*, the latter including *orbital* aneurisms. Internal aneurisms are also designated by the name of the vessel involved.

They all present certain **clinical phenomena** in common: (1) The development of an elastic *pulsating tumor*, which is diminished in size by pressure on the tumor or the artery on the proximal side of it, and increased in size by pressure upon the artery on the distal side; (2) *aneurismal murmur* or *bruit*, heard over the tumor; (3) *signs of pressure*, as absorption of neighboring parts and tissues, even bone; *pain* and *paralysis* from pressure by the tumor on adjacent nerves.

Results of Aneurism.—An artery involved in aneurismal dilatation never returns to its normal state; the dilatation, if changed at all, tends steadily to increase. The walls become thinner and weaker, and, while the irritation may develop an increase of tissue in the vicinity, it is unable to furnish an efficient substitute for the loss or attenuation of the original arterial coats. The sac ultimately gives way at some point, and in the case of aortic and other dilatations affecting the larger vessels fatal hemorrhage ensues. Fatal cerebral hemorrhage or apoplexy, and hæmoptysis in pulmonary tuberculosis, may result from the rupture of minute or miliary aneurism. An untreated aneurism may also cause death by pressure on important parts, by inducing syncope or by causing gangrene.

Spontaneous cure—unfortunately, a rare termination—may be effected in several ways, and the modes of treatment subsequently to be considered are but imitations of nature's methods:

(1) The most frequent method is by the *gradual deposit* and subsequent *consolidation of laminated coagula*, and is seen almost exclusively in sacculated aneurisms and arteries of the second or lesser magnitude, the dilatation forming a diverticulum in which the blood circulates more slowly, and the morbid condition of the intima in addition favoring the formation of a coagulum in successive layers, thus encouraging

the separation of fibrin and the consequent formation of a laminated clot. Stanley observed an aortic aneurism spontaneously cured in this way. This mode of cure is imitated in the medical treatment of aneurism, as well as the surgical treatment by pressure on the cardiac side of the aneurism, by flexion, and to a certain extent by Wardrop's operation.

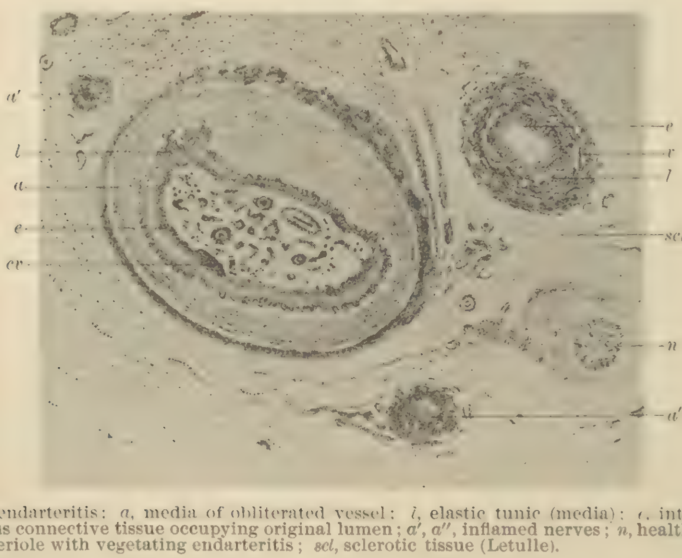
(2) The artery below the sac may be *plugged by an embolus* from the previously formed coagulum, or the artery above the sac may be occluded by an embolus from the heart or another aneurism, the former being imitated by Brasdor's operation and the treatment by manipulation; and the latter by Anel's method.

(3) Irritation of the sac may cause *coagulation within*, and is imitated by direct pressure, galvano-puncture, and the injection of irritating fluids. The clot formed in this way is apt to be soft, and may subsequently disintegrate.

(4) Finally, by *suppuration and gangrene* previously occluding the artery and extruding the sac as a slough. This is the method of the "ancient cure," or the operation of Antyllus, which practically is an excision of the aneurism.

When spontaneous cure results the sac becomes firm and contracted, the pulsation and bruit disappear, the circulation being carried on by collateral branches. It is only in comparatively small arteries that we may expect complete obliteration spontaneously by filling up of the sac with cicatricial tissue, the formation of such tissue probably being preceded by the occurrence of a thrombus in the sac, subsequent organization of the thrombus, and the development of collateral cir-

FIG. 228.



Chronic endarteritis: *a*, media of obliterated vessel: *l*, elastic tunic (media): *e*, interna: *cr*, fibrous connective tissue occupying original lumen; *a'*, *a''*, inflamed nerves; *n*, healthy nerve; *v*, arteriole with vegetating endarteritis; *scl*, sclerotic tissue (Letulle).

culation. In large aneurisms we frequently find large, firm, laminated, partly decolorized or mottled thrombi more or less completely occupying the cavity. At various points we may find evidence of partial proliferation of the elements of the intima in contact with the thrombi, leading to the development of fibrous tissue; but such thrombi rarely if ever undergo complete organization, affording but an

imperfect defence against rupture, as the blood may find its way between the thrombus and the vessel-wall, and the thrombi may undergo softening, disintegration, and even liquefaction; sometimes calcareous salts are deposited, and they become calcified. In rare and occasional instances of fusiform or tubular aneurisms, even in comparatively large arteries, observed principally in the aorta and the larger branches, laminated thrombi may also entirely fill the cavity of the aneurism, leaving a canal for the passage of the blood, and by hyperplasia and hypertrophy the different tunics become greatly thickened and increased in strength and density, the effect of gradual and long-continued interstitial deposits of fibrous tissue, resulting in spontaneous cure.

ETIOLOGY.—The development of an aneurism is due invariably to pre-existent disease or injury of the arterial coats, *sclerosis* or *atheroma*

FIG. 229.

Aneurism of an artery from the pia mater, of mycotic-embolic origin: *a*, adventitia; *h*, hyaline intima covered with thrombi; *r*, red thrombi (Eppinger).

being the commonest cause. Sacculations are especially apt to occur when the intima and media are simultaneously affected by active disease or degeneration. Affections of the adventitia may lead to aneurism when they are such as extend to the media and occasion muscular degeneration there. These conditions all diminish the elasticity and strength of the arterial wall, so that the pressure of the blood causes it to stretch and give way. We usually find the intima wanting or highly atheromatous, the muscular elements of the middle coat being lost altogether or fatty and degenerated, the elastic fibres showing granular change. The intima or media, or both, may here and there be wanting entirely, while the adventitia is usually thickened and infiltrated with

exudations. According to the Ponfick,[1] emboli consisting of calcified endocarditic vegetations may lodge in the wall of an artery—possibly of the brain, for example: there they work or bore their way into the tissue of the wall until it at length gives way and a sacculation is formed.

Age has an important influence on the occurrence of aneurism. We find by far the majority of cases occurring about the middle period of life, the decade from thirty to forty years of age being that in which we have by far the greater frequency of occurrence of atheromatous degeneration, while at the same time the heart has not lost any of its impulsive force; there are more frequent calls upon the entire muscular development for periods of increased and extraordinary exertion, and when the degenerated vessels, enfeebled and inelastic, becoming exposed to powerful causes of distention, may readily give way or be dilated at some one weakened point. After the age of forty the heart's action, as well as general muscular force, gradually becomes weakened, and we find the frequency of occurrence gradually decreasing. Aneurism is rare before the age of puberty, the few occasional cases being rather surgical curiosities. Erichsen says that "Syme mentions a case of popliteal aneurism in a boy of seven;" Hodgson had a preparation of a carotid aneurism in a girl of ten, and Schmidt a case of spontaneous aneurism of the radial artery in an infant eight weeks old. R. W. Parker, after a careful search of medical literature, only found 15 cases recorded as occurring under the age of twenty. Gross says that "men suffer from aneurism more frequently than women, but in what proportion has not been determined." The same principles influenced by age govern *sex*. *Occupation* also has its bearing, and we find a greater frequency of occurrence in those subjected to occasional over-exertion of muscular and cardiac force. *Climate* also has its influence, and we find a greater frequency in cold than in hot countries: it is not so much locality and meteorological influences, however, as it is the habits of the people that predispose to it. *Cachexy*, induced by any cause, as syphilis, rheumatism, gout, errors and excesses in diet having a tendency to develop structural changes in the arterial coats, is of importance as a factor. *Embolism* is an occasional cause, noticed most frequently in the popliteal artery, producing first obstruction in the calibre of the vessel, and then softening, disintegration, and dilatation of its walls.

THE DIRECT AND EXCITING CAUSES are limited to *blows*, *wounds*, violent muscular *strains*, or increased cardiac impulse even from mental excitement or other causes. The degenerated coats may give way under the influence of a direct blow or concussion, or severe muscular exertion or inordinate force of ventricular contraction unduly stretching the inelastic vessel.

Varieties.—Various classifications have been observed by different authors. I can but regard the following as being full and complete, and more in accordance with the general features presented, simple, and readily understood:

1. SACCULATED OR SACCIFORM ANEURISM:
   This may result in—
   A. *Hernial aneurism;*
   B. *Diffused aneurism*, the latter being a form of *False aneurism.*
2. CYLINDRICAL, TUBULAR, OR FUSIFORM ANEURISM.
3. DISSECTING ANEURISM:
   This may become—
   1. *Sacculated;*
   B. *Diffused and false aneurism.*
   C. *Circumscribed aneurism.*

[1] *Virch. Arch.*, vol. lviii.

4. TRAUMATIC ANEURISM.

This may be—

C. *Circumscribed,*
B. *Diffused;*
D. *Arterio-venous,* { *f. Aneurismal varix,* / *g. Varicose aneurism,* } *e. False aneurisms.*

5. ARTERIAL VARIX AND CIRSOID ANEURISM.

6. ANEURISM BY ANASTOMOSIS, OR ANGEIOMA.

(1) **Saccular Aneurism.**—Of the two grand divisions, according to this classification, we find the saccular the most frequent. It essentially consists of a formation of a pouch, bag, or sac connected with the side of the affected artery. It may even develop from some point of a cylindrical or tubular dilatation or aneurism. It is capable of assuming a great variety of forms, the most common being globular or ovoid—in rare cases, conical, elongated, or irregularly flattened. It may vary materially as regards dimensions, in some instances not being larger than a hazel-nut; in others it is as large as the fist or even the head of the patient; in general, however, so long as it remains a simple sacculated aneurism it is not larger than an orange.

The attachment of the tumor to the artery is commonly by a narrow footstalk, but in some instances it is by a broad and extended base, in which case it is not unusual for the artery to suffer serious compression during the progress of the tumor. The orifice of communication in the first method of attachment is proportionately small, with smooth and well-defined margins. In the latter it is always much larger, its edges irregular, sometimes quite shreddy and ragged, as if the vessel had been rent or torn. The internal and middle tunics may terminate abruptly at the margins of the sac or may extend into its cavity, and serve for, at least, a partial lining. By the rapid proliferation of tissue in the adventitia and media there is usually such a blending of the various elements that the separation of the several coats in an aneurism of large size becomes very difficult if not impossible. So long, however, as the external coat remains intact, it may be regarded as a simple sacculated tumor.

The first thing that happens is the loss of tensile strength of the middle coat through pre-existing disease of it and the intima, or possibly a rent, fissure, or crevice, which gradually enlarges under the influence of the impelling current of blood, and thus permits the corresponding portion of the elastic adventitia to be converted into a pouch. This pouch, originally composed exclusively of the adventitia, would be very weak and unable to withstand the shock of blood driven into it. Nature, however, comes to the rescue, and under the influence of irritation, caused by pressure of the developing tumor, pours out both in the adventitia and adjacent tissues plastic matter: this effusion rapidly becomes organized, blending the tissues together in a firm and more resisting mass. Under the same influences there may be more or less proliferation of the muscular elements belonging to the media, as well as, in some cases, the interior being lined, if not with a perfect, yet a fair ensemble of the intima. "Such aid, then," says Gross, "is wise and needful, and, fortunately, always comes into play at an early stage of the disease," the yielding of the arterial coats, the pressure of blood within, and the pressure of the tumor on adjacent structures developing sufficient irritation from the rapid effusion of plastic exudates and the proliferation of cellular and other elements. Gross further says: "When the periosteum contributes to the formation of the sac, as it occasionally does in aneurism of the thoracic aorta, the walls of the tumor may be partly earthy, or even partly osseous."

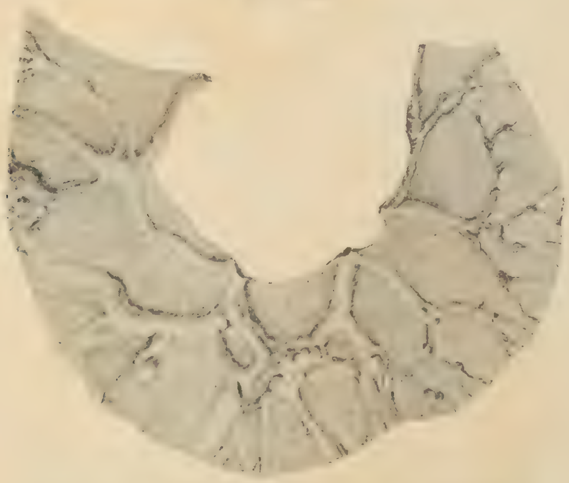
Hamilton[1] says: "It is possible that an aneurism may be sacculated without a lesion of either the internal or middle coats of the artery; that is, like the fusiform aneurism, it may be formed by a dilatation of all the coats. This condition, however, can never obtain except in the case of small aneurisms, and even in these

[1] *The Principles and Practice of Surgery*, p. 197, 3d ed., 1886.

cases its occurrence must be regarded as altogether exceptional. In almost all cases one or both of the internal coats have given way, and the sac is composed only of the external coat, with such adventitious coverings as a certain degree of inflammatory action may have provided."

The *sac* varies in thickness, in different cases and under different conditions, from the fourth of a line to the fourth of an inch thick, or even thicker, at some points as the tumor develops the sac becoming much thinner than at others. Usually the sac is quite tough, and in cases of long standing is composed of various strata, grayish, whitish, or drab-colored, consisting of fibres intersecting each other in all directions. The outer surface is rough and irregular; the inner, if at first smooth, subsequently becomes rough and encrusted with fibrinous concretions. Notwithstanding the thickness of the sac and the reparative effects of nature by means of plastic exudation, owing to the absence or deficiency of the muscular fibres it gradually dilates under the continued influence of the inflowing blood-stream, and at one or more points manifests a disposition to yield, and at length gives way, the activity

Fig. 230.



Multiple aneurisms of the mesenteric arteries (Eppinger).

of the absorbent vessels, according to some writers, exceeding those of repair.

The sac always contains, even at an early period of formation, fibrinous masses, that not only strengthen the tumor, but aid in its obliteration, and in rare instances its spontaneous cure. They are arranged in concentric layers or laminæ piled one upon the other, and closely connected with one another and with the wall of the sac. Their color and density vary according to age of development, the outer and older being pale and yellowish and of a firm, fibrinous consistency, while the inner ones, of more recent date, resemble very much an ordinary blood-clot; in thickness they range from one-fourth of a line to that of a sheet of paper, and may number several hundred in an aneurism the size of an orange. The diminished movement of the blood in the sac, and the altered conditions of the sac-wall from that of normal endothelium, cause the deposition of fibrinous material in which is entangled both white and red blood-cells, and, as the fibrin contracts after deposition, the red corpuscles are squeezed out or disintegrate and again mingle with the fluid blood, the leucocytes, or a part of them, and the fibrin remaining, to

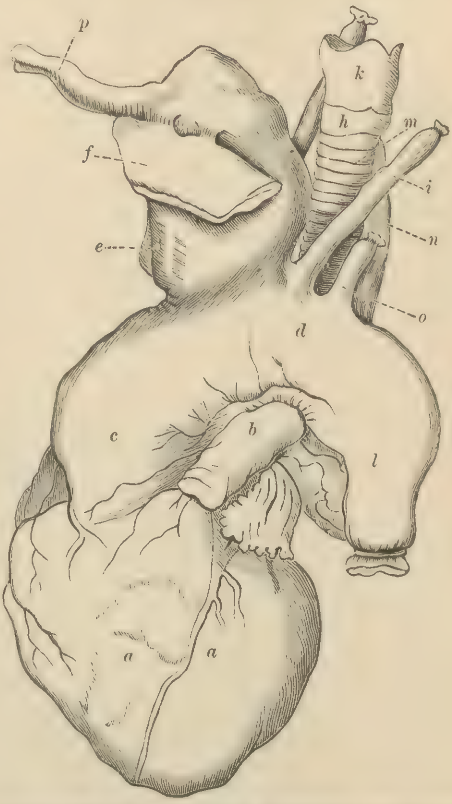
PLATE XVII

Large Aneurism of Ao[illegible] Consolidation. (Specimen [illegible] sity of Buffalo.)

subsequently become organized into a lamina. In the older layers no corpuscles are distinguishable, but much fatty and granular matter is found, the result of their disintegration. In fusiform aneurisms, in which the flow of blood is rapid throughout the dilatation, adhesion takes place with difficulty, while in sacculated aneurisms, the movement of the blood being retarded, laminated fibrin is nearly always deposited. It will afterward be shown that modes of treatment by which the flow of blood in the sac is retarded are of the greatest importance.

(A) *Hernial aneurism*, or aneurismal hernia, is of so rare occurrence that its existence has been questioned. Among the older writers, Haller, Dupuytren, Breschet, and others have given particular descriptions of it. It is saccular in form: the outer and middle coats having yielded to erosive or other destructive action, the inner coat is pushed out in the form of a thin translucent cyst. Pressure on adjacent tissues occasions interstitial plastic deposits, strengthening the sac. Soon, however, under the influence of continued blood-pressure from within, it will burst and result in a diffused or circumscribed hemorrhage, which subsequently may be walled in by adventitious material, forming (*e*) *a false aneurism.*

FIG. 231.



Aortic aneurism: *f*. sternum displacing clavicle; *e*, aneurism involving root of innominate (Cooper).

(B) *Diffused Aneurism.*—A sacculated aneurism may give way under erosive action or the influence of increased pressure from within, the effect of violent cardiac impulse, muscular exertion, or severe compression. Only a small quantity may escape, and if it should coagulate very firmly; the clot so formed may serve for a time as an effectual barrier against further loss. Most generally, however, the hemorrhage is extensive, and the newly-extravasated blood, mingled more or less with coagula of recent formation and not firmly adherent to each other and the wall of the sac, speedily coagulates, gradually assuming a greater degree of consistence if the patient survives any length of time, this additional pressure by irritative action rapidly producing the effusion of plastic matter and the proliferation of cellular tissue around the mass, walling it in and forming a new sac of increased dimensions. None of the arterial tunics forming part of the sac, it is one of the forms of (*e*) *false aneurism.*

(2) Tubular aneurism is an abnormal dilatation of an artery, all the

coats being expanded throughout the circumference of the vessel. It most frequently occurs in the aorta, though sometimes met with in the cranial and other vessels. It is not a mere fusiform dilatation of the artery, for there are elongation, thickening, and degeneration of the walls. The elongation of the artery may be as marked as the dilatation, and is always very considerable, an undue space being observed in cases occurring at the aortic arch between the innominate, carotid, and subclavian, its walls likewise being thickened, nodulated, and rugged. In some instances several dilatations are observed in the same vessel, with intervening healthy spaces. It rarely grows to be of great size, and scarcely ever ruptures unless a sacculated aneurism is developed from some portion of it. It rarely contains laminated coagula, but may give rise to great discomfort, and often becomes serious from pressure upon important organs.

(3) **Dissecting aneurism**, originally described by Shekelton, in which the sac is situated in the wall of the artery between its coats, is one in which the intima has given way by reason of atheromatous or other erosion, and the blood dissects or makes its way by splitting up the media. It may burrow for some distance through the media, and at some point may push out the adventitia, forming a saccular aneurism, or, bursting through an eroded spot, may be extravasated into the tissues, resulting in the diffuse form. It may also burrow through the middle coat for a distance, and reopen into the lumen of the artery through a more distant atheromatous patch of the intima: in this form it may last for years and the patient may live indefinitely, or it may form a blind pouch within the media: failing to push its way through the adventitia or intima, a sac is thus formed in the substance of the middle coat which may become chronic, but which will at last push its way through the external coat and rupture. The arterial coats often appear soft and sodden as if macerated, and are easily separated.

Two conditions are essential for its production: (1) an atheromatous condition, destroying the intima and the innermost layers of the media; and (2) there must also be a general softening of the middle coat, rather than a blending or matting together of its tissues by plastic exudation, with want of cohesion between the tunics. The rupture usually takes place in a longitudinal direction along the middle coat, and may often extend to a very considerable distance. The aneurism may reach from the end of the aorta to the iliacs, or from the aorta to the bifurcation of the carotids. It occurs almost exclusively in the aorta and its principal branches—in those arteries in which yellow elastic tissue is most abundant in the media. In some instances, when the blood re-enters the vessel through the intima, the new channel becomes lined with a dense smooth membrane, resembling closely the intima, from which it is separated as by a septum, and has been erroneously described as a double aorta. A dissecting aneurism may be sacculated, circumscribed, or diffused, and so constitute a false aneurism.

4. **Traumatic Aneurism.**—In an oblique, indirect, or small puncture of an artery the blood may partly escape from the wound, and partly be extravasated in the adjacent tissues; or, clot forming sufficiently to prevent the further escape of blood externally, we may have extravasation within; and in some instances the external wound may have been closed by plaster or bandage; the lesion of the artery remaining patent, the blood is forced out into the tissues. There may have been no external solution of continuity, yet the artery may have been punctured, lacerated, or torn across completely by fragments of bone, violent con-

tusion, strain, or twist of the part, by the injury of a dislocation, or the efforts of the surgeon at reduction.

(C) *Circumscribed Traumatic Aneurism.*—The blood, extravasated as above, may become surrounded and limited by plastic exudation; this by gradual development of fibrous tissue, after the nature of cicatricial tissue, may be sufficiently firm to prevent further diffusion, but not strong enough to resist the distending force of the cardiac contractions, and it steadily increases in size—not by a process of stretching, as it does not become uniformly thinner in proportion to its increase in size, but by a constant growth of new fibrous tissue. As the aneurism increases, however, the growth of fibrous tissue becomes less perfect, and eventually too soft to withstand the pressure of the blood, and the sac may rupture and the aneurism again become diffused or fatal hemorrhage result. Circumscribed traumatic aneurism most usually occurs from injuries to the smaller arteries, as the temporal, facial, palmar, plantar, radial, and ulnar.

Another form of circumscribed traumatic aneurism occurs but rarely, and is due to a small puncture of a large artery, as the carotid or axillary. At first the hemorrhage may be quite free, subsequently arrested by pressure; the external wound as well as that in the arterial coats may heal by cicatrix. This, being weaker than the normal arterial tissues, may, after several weeks or months, yield to the pressure of the blood, and a distinct sac, formed by the yielding of the cicatrix in the external coat and the arterial sheath, results, with no effusion of blood into the surrounding tissues, this being the only form of traumatic aneurism that possesses the features of a true aneurism.

FIG. 232.

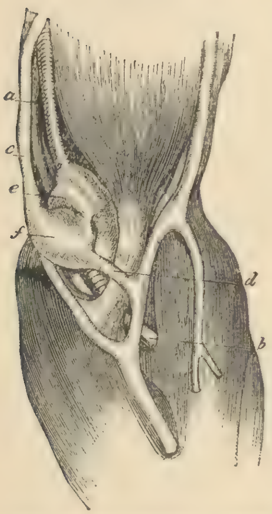
Traumatic aneurism of axillary artery (Park).

(B) *Diffused traumatic aneurism* exists when the blood forced out is only limited in extent by the resistance of the surrounding tissues and

coagulation in the network of areolar tissue. It has no sac, its boundary is ill defined, and it has a constant tendency to extend under the pressure of the fluid blood, which is continuously forced into the interior of the mass.

(D) *Arterio-venous Aneurism.*—In former days, when general venesection was so frequently resorted to, it was by no means uncommon for the adjacent artery as well as the vein to be wounded. When a contiguous artery and vein have been perforated, adhesion may take place between the two vessels at the site, the communication between them remaining pervious; a portion of the arterial blood is thrown directly into the vein at each pulsation, the vein being dilated into a fusiform pouch with thickened coats. Communicating veins may also become enlarged, nodulated, tortuous, and thickened, constituting (*f*) *aneurismal varix.*

FIG. 233.



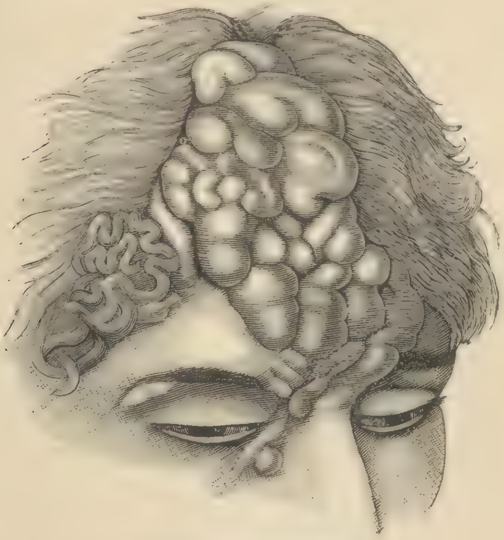
Arterio-venous aneurism at bend of elbow: *a*, brachial artery; *b*, radial artery; *c*, basilic vein; *d*, median basilic vein; *c*, aneurismal sac; *f*, dilated vein (Lenoir).

In some instances the openings in the artery and vein are not directly in communication, and a diffused or circumscribed aneurism, with its sac formed by plastic effusion and development of fibrous tissue, is formed between the two vessels, into which the blood is poured before reaching the interior of the vein, forming a *varicose aneurism*, which is a traumatic aneurism to which is added the conditions of aneurismal varix. In some instances the opening into the vein becomes closed, and the tumor is converted into a circumscribed traumatic aneurism.

(5) **Arterial Varix and Cirsoid Aneurism.**—This is a peculiar dilatation occurring in the scalp, and next in frequency in the hand, although other parts, as the tongue, viscera, bones, etc., may be involved. The artery is dilated, elongated, and tortuous, very much like a varicose vein. True aneurismal pouches sometimes form as large as the end of the finger or thumb. If a single artery is involved, it is known as arterial varix, and if a number of arteries, held together by connective tissue, are so affected, it is termed cirsoid aneurism. The structure of the arterial walls in the beginning shows no change, although subsequently they become thinned during the process of dilatation and elongation. Some authors have argued that this is not properly an aneurism, but, having some of the peculiarities pertaining thereto, it is deemed best to consider it in connection therewith. It is especially the middle coat which is most affected, becoming pale, soft, and thin, the artery now resembling a vein in structure. The dilatation is commonly symmetrical, so that the circumference of the artery is uniformly dilated; in other cases, however, this not being the case, we have pouches and unequal saccular dilatations. As the artery elongates it becomes tortuous and serpentine, sometimes even spiral. It is rarely limited to a single trunk, several trunks and their branches being involved. These

growths rarely occur in infancy, generally making their appearance in early adult life as the result of a bruise or injury, causing, as some sup-

Fig. 234.



Cirsoid aneurism (Bruns).

pose, a paralysis of the vasomotor nerves. The tumor is irregular in shape, compressible, bluish in color, and pulsating.

(6) **Aneurism by Anastomosis, or Angioma.**—While not properly a neoplasm, but rather a morbid change affecting a vascular area in which the arteries become dilated and convoluted and the intervening tissues subject to atrophy, its consideration here is proper, although by some it is not considered as an aneurism. The tumor pulsates, and feels under the fingers like a knot of moving worms. In some instances it originates in congenital defects, and at times leads to erosion of bone; in other cases it is evidently the result of mechanical injury. The walls of the dilated arteries are thickened. It differs from cirsoid aneurism in that the capillaries are dilated and the skin is involved. It will generally be noticed that the arteries leading up to it, though at a considerable distance, are tortuous and dilated, with thin and distended coats, pulsating forcibly, constituting the condition of cirsoid dilatation. The temperature of the part may be somewhat elevated.

Symptomatology and Diagnosis.—The leading symptoms in external aneurisms are usually sufficient for a ready diagnosis. The development of a tumor in the course of an artery, ovoid or globular, except in the case of diffused or tubular aneurisms, soft and elastic to the touch, is usually well defined. This, if taken in connection with pulsation and a well-marked bruit, forms pathognomonic phenomena not likely to be mistaken for anything else. However, if the tumor is not of recent formation, it may be firm and resistant from accumulation of more or less organized coagula within and density of the sac. The fluid nature of the contents is usually perceptible. A cystic or other tumor,

located over the course of an artery may receive an impulse therefrom, which, however, would be likely to disappear if placed in a dependent position, or, if it is lifted up from the artery, the impulse in such case being more of a lifting, heaving character, in a line drawn from the centre of the artery to the centre of the most salient point of the tumor; while in aneurism it is eccentric, expansive, and centrifugal, being felt with almost equal force over the entire circumference of the tumor. In case of a tumor over a large artery the impulse usually increases with the size of the tumor, and in aneurism it naturally decreases. In grasping the tumor between the ends of the fingers applied to both sides its expansive character in aneurism is quite apparent. The pulsation is more forcible in an aneurism in which there is but little laminated fibrin, and as this increases the pulsation loses its expansile character, being converted into a dull *thud*, and in some cases is lost entirely. When pulsation is ill defined it may be increased by elevating the limb or compressing the artery below the tumor. Firm pressure above the tumor will cause the pulsation to cease, and the size of the tumor may be somewhat reduced by pressure at the same time over the tumor. Taking the pressure from the artery suddenly, the blood will rush into the tumor and distend the sac by a sudden stroke more or less expansile in character.

The *bruit* or *murmur* accompanies the pulsation, and may vary materially in different instances, as was first noticed by Ambrose Paré, and is caused by friction and ricochetting and tumult of the blood passing into and out of the dilatation. It is usually loud, rasping, and blowing —loudest and roughest in tubular aneurisms. Occasionally in sacculated aneurisms the bruit is double, and in cases of aortic regurgitation we may have a diastolic murmur in fusiform aneurism from the backward flow of blood in the large vessels. In many cases the bruit is entirely or occasionally absent, especially in sacculated aneurisms with small mouths, in those that are distended with coagula and blood, and in more quiescent states of the circulation. In the latter case exciting the circulation by muscular exertion or otherwise may develop a bruit that at other times may not be detected. Elevating the limb may slightly reduce the quantity of blood in the sac, and render perceptible a bruit too feeble to be detected otherwise. Pressure over the artery leading to the sac will usually cause cessation of bruit.

In encephaloid tumor, soft sarcoma, and growths of nævoid tissue we may have reduction of volume by pressure, and the distinct impulse of blood may be felt on its removal, the tumor returning to its original size with a soft swelling pulsation, and there may also be a loud and distinct bruit. These tumors are not so distinctly circumscribed: they are soft, spongy, and elastic, not having the sensation of fluid met with in some forms of aneurism, or of solid coagula as found in others; and the bruit is either soft, blowing, and more prolonged, or possibly sharp and superficial; the pulsation also is not so distinct, and is more of the nature of a general swelling or heaving of the tumor than a distinct thud. The location of such tumors, if in a situation not occupied by an artery of sufficient size, as the head of the tibia, the side of the pelvis, etc., may solve the difficulty; but if such a tumor is located over or under an artery of large size and in the usual site of an aneurism, the diagnosis may be extremely difficult. An abscess located over an artery and in a favorable site for aneurism may present diagnostic difficulties. The history of the case, impossibility of diminishing the size of the tumor by pressure over it or on the artery on the proximal side, its want of circumscription, its fluctuation, and a distinct heaving up and down, instead of the eccentric and expansile

pulsation pertaining to an aneurism, may serve to elucidate. Glandular or thyroid swellings over the carotid, or similar conditions elsewhere at the root of the neck or in the groin or popliteal space, may likewise present difficulties. If solid, they are usually nodulated and irregular in outline, and can be frequently moved to one side of the arterial site or lifted up from it by passing the fingers beneath; yet care must be taken not to mistake them for a consolidated aneurism undergoing spontaneous cure. Difficulty is especially apt to occur in aneurisms that have become diffused, either spontaneously or as a result of traumatism, that may not pulsate, have no bruit, are elastic, softened, and diffluent to the touch, and over which the skin may have become inflamed and reddened. It is only by the most careful attention to the history of the case and by skilful manipulation that a correct diagnosis can be arrived at. Withdrawing a part of the fluid contents by the cautious use of a small aspirator needle may fail to elucidate the case satisfactorily, for the aneurism and abscess may exist coincidently, or the artery and abscess may communicate as a result of erosive action.

Rheumatism and neuralgia have been mistaken for aneurism, and *vice versâ*, especially in internal aneurisms. The pain in aneurism is not only lancinating, but intermittent, as well as continuous, aching, boring, and burning. In many cases of popliteal aneurism the patient first complains of rheumatic pain in the knee, and it is a good rule whenever complaint is made of obscure pain in the knee-joint, persistent in character, to examine the popliteal space, as well as similar pain in the back, side of the head, neck, or arm should occasion a careful scrutiny of the neighboring large vessels.

The *skin over an aneurism* may be healthy or natural in color, though it is stretched: as the aneurism grows it may become discolored, thinned, and even ulcerated, and suppuration may occur in the subcutaneous areolar tissue. Muscular weakness, stiffness of the part, and a tired feeling are accompaniments.

Venous congestion and *œdema* from compression of the deep-seated veins, and in some cases a varicose condition of the superficial veins, and even gangrene and superficial sloughing from obstruction to the returning circulation, are among the effects sometimes present, the tendency to *gangrene* being increased by the pressure of the sac upon its own or neighboring vessels. *Pressure upon nerves* not only gives rise to lancinating pain, but also to interference with the functions of important parts, as hoarseness and spasmodic dyspnœa from compression of the recurrent laryngeal, dyspnœa and uncontrollable eructation from pressure on the pneumogastric, and facial paralysis, deafness, ptosis, strabismus, and blindness in cases of intracranial aneurism. Pressure upon secreting glands or their ducts may cause trouble from interference with their functions, death from asthenia and progressive emaciation having occurred from pressure upon the thoracic duct prior to rupture of the sac. Serious consequences may ensue from pressure upon important viscera, or dyspnœa and cough from compression of the trachea, bronchi, or lungs; dysphagia from pressure on the œsophagus; or hemiplegia as a result of an intracranial aneurism. Serious consequences result from pressure upon bones and joints; the flat bones, as the ribs and sternum, and even the bodies of the vertebræ, may be eroded, or caries and destruction of an articulation may ensue. The erosion of bone by an aneurism is usually attended by a distressing sensation of boring or burning pain, as in the vertebral column in cases of aortic aneurism.

When an aneurism becomes diffused by *rupture of its sac* the tumor loses its defined outline, rapidly becomes much larger, and the pulsation and bruit may become weak or disappear. The part becomes œdematous, cold, and livid from venous congestion; pain is suddenly increased, and

syncope may occur. The swelling becomes hard from coagulation, and in some rare cases consolidation of clot, condensation of areolar tissue, and plastic effusion may limit its further extension, and so grave a result has resulted in spontaneous cure. Generally, however, the swelling increases, with or without pulsation, and the case ends in gangrene or external hemorrhage from giving way of the superjacent tissues. In other cases rupture of the sac leads to wide extravasation of blood into the tissues, with shock and pain, faintness and syncope from loss of blood from the general circulation, and death at no distant day from exhaustion or gangrene.

Diffused traumatic aneurism is, as Gross remarks, a collection of blood in the tissues of the part, differing only from a wounded artery in there being no external communication. The diagnosis can usually be readily made by reason of the oblong, somewhat pyriform swelling, elastic and fluctuating, and, if the opening into the artery is large, we may have well-marked pulsation, thrilling, purring or jarring, and bruit, although in some cases one or both may be wanting; the pulsation of the artery beyond the wound is either diminished or wanting. At first the skin over it is natural in color, but gradually becomes bluish, and thinned by pressure. Circumscribed traumatic aneurism in the clinical phenomena presented differs but little if at all from the forms already given. In all cases we may expect to find the pulsation in the artery beyond the aneurism diminished.

General Treatment.—Measures to prevent further increase of the dilatation, the formation of organized coagula, and the obliteration of the sac pertain to the domain of therapeutics as well as surgery, and surgical means may be greatly enhanced thereby. In some instances they constitute the sole reliance, the object being, first, to lessen the force of the cardiac impulse, and so diminish the eccentric pressure of the blood; and, second, to modify the condition of the blood so as to dispose to the deposition of fibrin. Perfect *rest*, in bed if possible, and a limited diet, avoiding irritation or indigestible food and stimulants, with a restricted quantity of liquid, as well as mental quiet, are of the greatest importance.

General venesection, originally introduced by Valsalva as a means of removing plethora and reducing irritability of the heart and the force of its action, may be advantageously employed in suitable cases. Valsalva combined with it a reduction of food and drink just within the starvation point. The *rest-treatment*, or the method of Tuffnel of Ireland, who first published his experience in 1875, has for its object the reduction of the watery elements of the blood and an increase in its solid constituents, and combined *rest*, *regimen*, and *restrictive diet*, with some remedial agents. Recumbency is the principal element of cure, and must be rigidly maintained for at least three months. His diet may be summarized as follows:

Breakfast.—Two ounces of bread with a little butter and two ounces of milk.

Dinner.—From two to three ounces of meat without salt and four ounces of milk; for a portion of the milk an ounce or two of claret may be substituted.

Supper.—The same as the breakfast.

With this he gave lactucarium to quiet the patient, resorting to opium if needed to relieve pain. He claimed that no remedial agent would so lessen the heart's action, without injury or danger, as rest in the recumbent position. He also gave compound jalap powder at intervals to reduce the quantity of the blood by withdrawing the serum.

Iodide of potassium, from its effect of increasing the deposition of fibrin, has been largely used by various reliable observers, and it has evidently been productive of good even in cases not due to syphilitic disease of the artery. Given in doses of from 5 to 30 grains three times a day, alone or combined with the bromides, suffering has been

relieved, there has been diminution in the size of the sac, and in some cases a cure has been apparent. Gallic acid, plumbi acetas, and chloride of barium have been recommended. Veratrum viride, aconite, and digitalis have also been claimed as advantageous: the two former, by modifying the heart's action, will doubtless be beneficial, although danger will likely attend the use of the latter by its effect of increasing ventricular systole. Langenbeck and Plagge have recommended the use of ergotine hypodermically.

S. Solis Cohen in two cases of aneurism at the root of the neck, presumably carotid, used hydrated calcium chloride in doses of about a drachm a day, in combination with rest. Marked improvement was demonstrated in one case, no change in the other. Marked improvement was also observed in a case of innominate aneurism under his care at the Philadelphia Hospital two years ago by similar measures.

These remedies, or some of them, judiciously used, will in all cases materially aid purely surgical procedures, and in cases when operative interference is questionable or directly contraindicated will at least prove beneficial if not curative.

Operative Measures.—First in importance is *ligation*, whether by the "old method" of Antyllus, extirpation and ligation of all vessels belonging to the sac; *Anel's operation*, or *proximal ligation* in the immediate vicinity of the sac; *Hunter's method*, or *proximal ligation* at a distance from the sac; *Brasdor's procedure*, of *distal ligation* below the sac; or *Wardrop's modification* of the same, by ligature of one or more of the principal branches given off from the artery below the sac. In all cases a proper preparation of the patient by rest, attention to diet and the emunctories, should not be lost sight of, and an effort to establish in advance the collateral circulation by compressing for a few hours daily the artery involved should not be neglected.

Dr. Joseph Ransohoff of Cincinnati, in a short paper contributed to the Am. Med. Ass'n., June, 1893, on "Extirpation of Aneurisms," gave the following conclusions:

"1. Extirpation is the ideal method. It should be resorted to unless there are weighty reasons against it.

"2. In aneurisms of the forearm and legs no other method should be adopted.

"3. Aneurisms which have suddenly grown large from subcutaneous rupture of the sac, and those in which rupture is pending, should be subjected to extirpation.

"4. In recent traumatic aneurisms the injured vessel should be divided between ligatures; when a sac has formed it should be excised.

"5. When other methods have failed, extirpation should be tried before resort is taken to amputation.

"6. In arterio-venous aneurisms extirpation should be practised if any operation is indicated.

"7. Proximal ligation is to be reserved for cases of idiopathic or spontaneous aneurisms in which the age of the patient or an enfeebled condition from other causes would make a prolonged operation hazardous, and for cases in which the position of the tumor precludes the possibility of extirpation."

Nearly forty years ago Mr. Syme suggested that in aneurism of the carotid, axillary, gluteal, and iliac arteries, in which the Hunterian method is not admissible, the sac should be *freely opened*, its contents turned out, and the artery ligated above and below. In several instances following the suggestion he was brilliantly successful, the last one being an aneurism involving the external iliac, his incision into the

sac extending for six inches, and six pounds of blood and fibrin were turned out; the common, external, and internal iliacs were ligated, with recovery of the patient. As regards effectiveness, extirpation has many advantages, but is, unfortunately, not admissible in some cases.

Hunter's method, although claimed as a modification of Anel's, but originated independently, is next in value. One of its advantages over the latter is that we are more likely to find sound arterial tissue at a distance from an aneurism than in its immediate vicinity. These two methods, as well as extirpation, are often excluded by reason of the site of the aneurism and the vessel or part of it involved.

In ligation in the immediate vicinity of the sac we are less apt to have maintenance of the circulation in the tumor by development of the collateral circulation, and as a result rapid but imperfect coagulation. In the Hunterian method we may have secondary hemorrhage at the site of the ligation, return of pulsation from too free development of collateral circulation, including the sac, sloughing of the sac, and gangrene of the limb.

Brasdor's operation aims to produce entire arrest of circulation in the sac, and *Wardrop's modification* a partial arrest. In addition to the same risks pertaining to Hunter's method, we are liable to have further distention of the sac or rupture of the sac or artery. It is limited to particular cases, as aneurism at the root of the carotid or of the innominate. The conditions and relations of each particular aneurism and the vessels involved are to be thoroughly and carefully considered, and the most suitable method resorted to.

Ligation is indicated in cases in which the trouble is active and progressive, in locations in which pressure and flexion are not applicable, in any cases in which other less dangerous modes have been tried unsuccessfully, in cases where a sacculated aneurism has suddenly become diffused or opened into an articulation, or where it has opened or is about to open externally, and in traumatic aneurisms. It is contraindicated when other methods, as pressure, flexion, etc., offer a reasonable hope of cure; in the presence of any complication, as extensive cardiac or arterial disease; the prevalence of erysipelas, which would likely affect the wound, or other circumstances incurring too great a risk; and by the locality of the aneurism being such that from the proximity of anastomosing branches or from any other cause the operation would be unsuccessful. Multiple aneurisms, though usually, are not always a contraindication: two aneurisms occurring in the same artery may be cured by the single operation, or a double popliteal by operation on both femorals. Their occurrence, however, suggests extreme caution.

Recurrent pulsation usually occurs after ligation within twenty-four hours, though sometimes not for four or five weeks, and still more rarely at an intermediate period. It usually disappears as consolidation takes place, though a fatal result may occur from sloughing of the sac. It is generally satisfactorily treated by elevating the limb, with moderate pressure over the sac. Enlargement of the sac without pulsation may result from reflux of blood on the distal side. If excessive, it may lead to gangrene, but generally coagulation occurs, converting the aneurism into a solid tumor. The treatment of hemorrhage at the point of ligation, sloughing, or rupture of the sac is by elevation of the limb, careful pressure, mechanical or digital; this failing, cutting down on the bleeding point and ligation above and below, or ligation of the main artery at a higher point, or amputation, must be resorted to.

Suppuration of the sac may occur in from a few days to several months *after ligation.* We first have heat, pain, pulsation, and discoloration of the skin: the latter, becoming thinned, at length gives way, and the contents of the tumor, softened, broken down, and mixed with pus, are discharged through the aperture in the form of a dark, purplish-brown fluid mixed with masses of soft dark coagula or drier laminated fibrin. The escape of this matter may be accompanied by a sudden gush of fluid arterial blood, carrying off the patient at once, or it may occur in small quantities, ceasing and recurring from time to time, gradually producing fatal exhaustion. It is most liable to take place between the third and eighth weeks, though in one case recorded by Sir A. Cooper it took place so late as the eighth month. If unaccompanied by hemorrhage, it requires only the treatment of an abscess, proper precaution being made to arrest hemorrhage should it occur during evacuation. If accompanied by hemorrhage, the case is quite serious. Evacuation of the sac by free incision, clearing out the cavity, and packing with iodoform gauze, held in place by graduated compress and roller bandage, may serve to permanently arrest the flow of blood, and will in all events give time to resort to more effectual means if needed. Ligation of the bleeding vessel is of doubtful utility; the softened and disintegrated vessel would be apt to give way. A ligature applied nearer the centre of circulation also is doubtful in its results: the circulation below, already embarrassed by the previous ligature and by suppuration and distention of the sac, may be so interfered with as to result in gangrene, or else the collateral circulation, if of sufficient activity to maintain vitality in the parts beyond the sac, will also keep up the hemorrhage from the artery or the sac. More certain results are offered by amputation of the limb if the aneurism is so situated that it can be done, or control of the hemorrhage by means of the actual cautery in other cases.

Acupressure and temporary ligature have been successfully used in a few cases, not sufficiently numerous to demonstrate any superiority over the ligature, and resulted in cure by temporarily arresting the flow of blood through the sac and consolidation of its contents.

Compression as a means of cure may be instrumental or digital—directly over the tumor or indirectly over the artery above or below (proximal or distal), or by means of the elastic bandage. In either event proper and careful precautions to favor occlusion should precede and accompany the effort. The irritability of the heart and general system should be controlled by anodynes and sedatives, and the patient placed in a comfortable bed and his position secured by well-adjusted pillows and mattresses. In irritable and uncontrollable patients it is not advisable.

Various instruments for this purpose have been devised, or the surgeon may improvise one to suit the special indications of the case.

Tuffnel has devised a very ingenious compressor, composed simply of a truss-spring and pad, with straps to keep it in place and to increase the force of pressure by being tightened.

Signoroni's tourniquet and Lister's aorta-compressor are applicable in certain situations.

A *conical weight*, held in position by means of a leather socket, a bag of shot suspended over the artery, as successfully used in Bellevue Hospital, New York,

may be used. It is not necessary, as was formerly supposed, to make such compression as to entirely occlude the artery, but just sufficient to simply arrest pulsation in the sac, without completely arresting the flow of blood through it, and thus induce the deposition of laminated coagula. After recovery the sac is generally entirely filled up, but in some cases the channel remains, through which the normal circulation is carried on. Instrumental pressure has given better results in aneurism below the middle of the thigh than elsewhere, and is not so applicable in the carotid, iliac, subclavian, and axillary arteries, although aneurisms in the groin have been successfully treated by compression of the external iliac or abdominal aorta.

The rapid-pressure treatment, by completely arresting the flow of blood through the sac by instrumental pressure both above and below the sac, and kept up for several hours, the patient being partly or wholly under the influence of an anaesthetic, while a valuable addition to the means of treating abdominal aneurism, is not so satisfactory in other situations.

Direct pressure, for obvious causes so dangerous and uncertain, and distal pressure, are now rarely resorted to, but both may prove valuable adjuncts to proximal compression. Before applying the instrument the part should be well shaved and dusted with talcum or other powder, and if an extremity is involved a soft roller should be carefully applied. In order to keep up continuous pressure, at the same time prevent the skin from being chafed or the soft parts beneath the pad from sloughing, it is best, if applicable, to adjust two instruments, the one above the other, a little distance apart, so that one can be tightened and the other temporarily loosened. The more continuously the pressure is kept up the greater certainty of effective results. It must be maintained carefully for a variable period. In some instances the tumor has solidified in a few hours, in others in two or three days, and it has been protracted from time to time for two or three months before cure has resulted. Barwell gives the longest period at seven weeks, and the shortest twenty-four hours.

Digital compression may be employed as an exclusive method of treatment or as an adjuvant to instrumental. If used exclusively, it requires several relays of competent assistants, relieving each other at periods of from ten to thirty minutes or longer in proportion to their powers of endurance, and it may be by the fingers or thumbs alone, or aided by a weight added to the hand or finger, or by means of a suitable compress. It is most applicable to arteries at the root of the neck, in the orbit, or elsewhere in cases in which an instrument cannot be adjusted.

In all cases of instrumental compression it is well to secure complete distention of the sac by a few minutes' distal compression. Careful elastic pressure over the sac during the whole course of treatment by compression is advised.

Compression has its disadvantages. It is sometimes unbearable by reason of pain, tedious in protracted cases, and occasionally fails. If venous congestion, great œdema, and pain are markedly increased, it should be abandoned if satisfactory results are not obtained in three or four days, and in exceptional cases in even a shorter time, and the Hunterian or other method resorted to. In the event of its failure the chances of cure by ligation may have been enhanced by the partial or complete development of the collateral circulation while being tried.

The *elastic bandage and tourniquet* have been successfully used in some cases of aneurism of the extremities. The bandage is tightly applied from the fingers or toes up the aneurism, lightly over the sac, and tightly again above it ; then the elastic tourniquet is secured, which should be

removed before the bandage, and instrumental or digital compression kept up for three, six, or twenty-four hours afterward, even if all pulsation in the tumor has ceased. The elastic bandage should be kept on for about an average of one and a half hours: it has been kept on for three to five hours without serious results. The limb must be kept warm by enveloping it in wool and the application of external heat to about 100° F. If the bandage be kept on longer than an hour, an anæsthetic or a full morphia hypodermic may have to be used. It effects a cure by causing stasis of blood in the sac and adjoining portions of the artery. It may fail from want of coagulability of the blood, and may result in gangrene from blood-stasis in the limb, venous thrombosis, or embolism from subsequent washing away of the clot or a part of it. It is not applicable to aneurisms that are large, have thin walls, containing fluid blood with no laminated clot, or are rapidly increasing in size.

Flexion, by bending the limb on itself, is limited to arteries low in the popliteal space or below in the leg, or in the arm below or at the bend of the elbow, and is further limited by pain and the insupportable annoyance due to confinement of the limb in one position. Although occasional temporary relaxation has been permitted, it has sometimes even then effected a cure. The limb is carefully bandaged as high as the knee or elbow, and then the extremity forcibly flexed upon the joint and maintained in position by a few secure turns above the joint or secured by a strap. It should be kept up for several days or a week or longer, and may precede or alternate with digital or instrumental compression in suitable cases.

Galvano-puncture, first employed by Phillips some sixty years ago, was but little resorted to until recently, when it has been warmly advocated by French and Italian surgeons, the object being to decompose the blood in the sac by means of galvanism, and thus secure its coagulation.

Erichsen advises ten or twenty Leclanché cells, with needles, both insulated to near their points with vulcanite or gum elastic, introduced into the sac on opposite sides, a current of high tension and somewhat low intensity being maintained for twenty or thirty minutes. Tillmanns uses a Stohrer's zinc-carbon battery, a fine sterilized needle ten centimetres in length being introduced into the sac connected with the positive pole, while the cathode or negative pole is connected to a metal plate on the opposite side of the tumor. The length of the sitting is only from five to ten minutes, and the current is gradually increased by rheostat and dynamometer from twenty to thirty milliampères. Bastian and others advocate the introduction into the sac of the positive pole only: the clot forming about the negative is soft and frothy, and but little good can result from it. A single application rarely suffices, and several are needed on different days to secure satisfactory results. It possesses no advantages over ligation or compression, and may result in sloughing, hemorrhage, or embolism. Its use is restricted to those cases, such as internal aneurism and others, not amenable to other methods, being positively contraindicated in diffused aneurisms.

Injections into the sac of perchloride of iron, ergot, and other remedies have been used in some cases with success, but the dangers from inflammation, gangrene, rupture, and embolism are far too great.

Manipulation, by kneading and squeezing the tumor in order to break up coagula that may have formed with the hope that a fragment may effectually plug the distal side of the artery, is both dangerous and uncertain: the embolus is not under control, and may lodge where it

will do serious injury. Esmarch, Teale, and Tillaux have mentioned such results from the necessary manipulations during the examination of an aneurism.

Acupuncture and the *introduction of foreign bodies* from without, coils of horsehair, catgut, and iron wire, to secure the formation of coagula, are also of questionable propriety, and should never be resorted to if more certain methods are available. Macewen's method of irritating the interior of the sac by means of a sharp needle, and thereby inducing the formation of white thrombi, has sometimes proved successful, the effort being to induce infiltration of the sac-wall with leucocytes from the blood-stream, and their segregation at the point of irritation. The irritation should be evenly applied over as much of the interior of the sac as possible, and at times, the needle being held lightly with its point impinging on the opposite surface so as to allow the current of blood to play on it, shifting to other positions at intervals of a few minutes. The time required to irritate the entire sac varies from a few hours to forty-eight hours. It may be necessary to repeat the operation at intervals for weeks or even several months.

Special Aneurisms.—*Thoracic aneurism* presents symptoms that are far from uniform, being due to pressure upon surrounding structures, and influenced by location, form, size, rapidity of formation, and direction of growth; being liable also to materially change during its progress. The symptoms are not in proportion to external manifestations: the more an aneurism tends in an inward direction, the greater the degree of suffering and disturbance, which may be intensely aggravated prior to any external manifestations. In some cases these may be very indefinite, with no physical signs whatever. Erosion of the sternum or ribs occurring, it may be readily apparent. Abnormal local sensations are usually present, such as pain varying in character and intensity; heat, weight, and fulness with throbbing; cutaneous tenderness and hyperæsthesia being common. When pressing backward the pain may be gnawing or grinding, owing to destruction of the vertebræ. Pressure-symptoms, occasioning interference with nervous and other functions, are to be closely studied. Aphonia, dyspnœa, or dysphagia may be manifested early or late. The general system may suffer markedly, and we may sometimes have a striking appearance of illness, combined with anæmia or a sallow, cachectic look, distressed and wan expression, without positive diagnostic phenomena. Gastric disturbance from pressure upon the pneumogastric or sympathetic nerves, and dysphagia, if œsophageal stricture and organic disease can be eliminated, are important symptoms. Head-symptoms with disturbed sleep may also occur.

Local bulging is dependent upon the site involved. If in the ascending or transverse portion of the arch, the prominence will be in front and to the right or left of the manubrium, occupying the remainder of the arch and the descending portion; the bulging will be posteriorly, generally to the left of the spine and occasionally to the right, and may become quite extensive. In shape it tends to be rounded and conical, and involves the ribs and spaces equally. Pulsation, if expansile, heaving, and throbbing, with or without enlargement, and synchronous with the cardiac systole, is an important sign: it

may be markedly undulatory, and sometimes a thrill is felt; it is sometimes double, and occasionally is mainly diastolic. If the patient is made to sit up with the head inclined forward, and the cricoid cartilage is grasped firmly between the index finger and thumb and drawn forcibly upward, putting the trachea on the stretch, a distinct and well-marked tugging sensation is felt, originally described by Surgeon-major Porter as *tracheal tugging*. Dulness upon percussion of a dead, putty-like character, extending beyond the cardiac areas, may be elicited over an aneurism, which is also to be discriminated from other mediastinal growths by exclusion or other characteristic phenomena. This is but one link in the chain formed by other symptoms. Auscultation may reveal nothing or only indefinite sounds. The most important is a rough murmur, usually systolic, sometimes double, and in rare instances only diastolic. Gross says that "it is more like the purring of a cat than the clear murmur of the first sound of the heart, and it is still further defined by the presence of a peculiar tremor or vibratory movement."

Occasionally a systolic murmur is heard over the trachea, or even at the patient's mouth when open. The heart may be pushed downward to the left: if the aneurism is behind, this organ may be so pushed forward that the chief impulse is observed at the base. The left ventricle may be enlarged, and aortic valvular disease is often present. Examination of the respiratory organs may reveal functional or organic disease of the larynx; displacement, compression, or interference with the entrance of air into one or both lungs; consolidation or destructive changes in them; bronchial catarrh on one or both sides, or bronchiectasis from pressure by the tumor. Dr. W. C. Glasgow of St. Louis, Mo., claims to have noticed a systolic thud in the brachial artery synchronous with the cardiac systole. The radial pulse may be delayed or absent on one side, or it differs in force on the two sides, and its dicrotism may be materially influenced. An aortic aneurism is not only capable of influencing the pulse by its direct effects upon the circulation, but by obstructing the main arteries by pressure and by closure of their orifices by torsion or clot. Osler says that a large aneurism of the descending aorta may cause complete cessation of pulsation in the abdominal aorta, femoral and peripheral arteries of the lower extremities.

As regards the form of aneurism, there is more diffused pulsation in fusiform aneurism, above as well as below the clavicle, well-marked thrill, rough, prolonged, rasping, whizzing or whirring murmur, systolic, louder along the arch than over the aortic orifice, and less prominence of pressure-signs.

The *duration of thoracic aneurism* may be only two or three months, or it may exist for as many years.

In the TREATMENT little is to be hoped from surgical interference, and our main reliance is upon therapeutic measures. Ligation on the cardiac side of the tumor is out of the question: an operation on one or more of the branches after Wardrop's modification of Brasdor's operation has not been as yet attended with results sufficiently satisfactory to justify very urgent recommendation, nor does acupuncture or galvanism offer encouragement. Should spasmodic closure of the glottis threaten to suddenly cut short the patient's life, opening the larynx or trachea is justifiable, as would be an opening into the stomach for the introduction of food in the event of distressing dysphagia.

The Innominate Artery.—Aneurism of this artery usually presents a pulsating, globular tumor behind the right sterno-clavicular junction: in addition to pain, we may have œdema of the right side of

the face and arm, laryngeal cough, dyspnœa, and dysphagia. The tumor will fill more or less the hollow above the sternum, rising as high as the lower margin of the cricoid cartilage; the sternal end of the sterno-mastoid is first pushed forward and subsequently the clavicular portion. The upper part of the sternum, the clavicle, and costal cartilage of the first rib may be pushed forward without the development of a tumor in the neck. Dulness on percussion around the sterno-clavicular articulation and pulsation of the first intercostal space are apparent. Bruit may be absent or very variable in character; the cardiac sound may be projected well up into the antero-inferior triangle of the neck. The pulsation in the carotid and radial on the right side is less than on the left, in many cases before the appearance of tumor. Enlargement of the superficial veins of the neck and upper extremities is a frequent accompaniment. Pain is not limited to the tumor, but may radiate into the neck or arm, over the shoulder and upper part of the chest. Entrance of air into the right bronchus may be interfered with. The muscular power of the right arm may be impaired. Pressure upon the sympathetic may occasion turgescence from dilatation of the vessels, and sweating on one side of the face.

Treatment.—In addition to a thorough attention to therapeutic measures, distal ligation only is admissible, limited to ligation of the subclavian alone, the carotid alone, or consecutive ligation of both; or galvano-puncture or acupuncture may be tried.

In **subclavian aneurism** the tumor extends externally to the clavicular origin of the sterno-mastoid muscle, reaching the posterior triangle of the neck: it becomes more elongated transversely than vertically; the bruit is propagated more toward the axilla than the neck, and remains the same on compressing the carotid; the radial pulse is enfeebled, and the limb painful, œdematous, and incommoded in its movements.

Medical and hygienic measures of treatment, with compression judiciously applied, are the most promising. The distal operation alone is applicable to aneurism existing in the first or second portions of the vessel, the Hunterian being limited to aneurism occupying the outer third, when the artery can be secured outside or between the scaleni muscles.

Ligation of the innominate, first practised by Mott, was successfully done by Smyth of New Orleans, who also tied the carotid and vertebral. Ligation on the proximal side and immediate amputation of the arm have been advised, and are perhaps justifiable in so grave a condition. The *N. Y. Med. Record* of Aug. 17, 1895, has the following: "A man was recently on exhibition in London whose innominate artery was tied by Mr. Coppinger, at the Mater Misericordiæ Hospital in Dublin, in January, 1893. The operation was for the relief of aneurism of the subclavian artery. He was exhibited shortly after the operation in Dublin, and later at Newcastle-on-Tyne. The man is now fifty-nine years of age, and is in excellent health. It is claimed for him that he is the only living example as yet exhibited in Europe of cure of subclavian aneurism by innominate ligature." Ligation of the innominate has also been recently done by Burrell of Boston, with temporary success.

Axillary aneurism, either idiopathic or traumatic, from the laxity of the surrounding tissues is prone to development and liable to become inflamed. Venous congestion and œdema of the forearm are likely to ensue. Delayed radial pulse on the side involved and severe pain from pressure on the brachial plexus are features.

Ligation of the axillary has been done, yet the statistics of ligation

of the third part of the subclavian have been more favorable, the first method being more after Anel's, the latter the Hunterian, method. Syme and Morton removed the arm at the shoulder-joint for hemorrhage and gangrene of the subclavian at the second part. Proximal pressure before resorting to ligation should be faithfully and carefully tried.

Aneurisms of the arm, forearm, and hand offer nothing peculiar in their clinical features.

When the upper part of the brachial just below the axilla is involved, digital compression or flexion may be tried. Instrumental pressure is apt to be very painful, and the smallness and cylindrical form of the humerus make it difficult of satisfactory application. If these fail, the operation of Antyllus is likely to be preferable to the Hunterian. For aneurism lower down or for either of the branches, if compression fail, the Hunterian operation can be tried. For traumatic or arterio-venous aneurism at the bend of the elbow extirpation is preferable. Aneurism of the hand if not relieved by pressure should be extirpated.

Aneurism of the common carotid presents a considerable degree of difficulty in its diagnosis, having in more than one instance been mistaken for aneurism of other vessels, solid cysts, abscesses, or other tumors by careful and experienced surgeons. Dilatation of the internal jugular vein, which may receive a pulsatory movement from the heart or the vessel, is distinguished by its softness and compressibility, the lack of expansile impulse, its situation, rather behind than in front of the mastoid muscle, and pressure upon its distal portion effacing it. In aneurism of the aortic arch, innominate, and subclavian the delayed impulse at the radial should aid in the diagnosis.

Ligation of the common carotid has been attended with a considerable degree of mortality, in many cases death resulting from cerebral or pulmonary sequelæ. If the aneurism is located low down, the proximal operation may be impossible, and ligation of the innominate for cases occurring on the right side is far too serious. Digital compression may be unavailable, and the only resort is to the old operation, the distal operation by Brasdor's method, or Wardrop's modification, one of the latter methods being preferable from the possibility of mistaking aneurism of the arch or the innominate for one of the common carotid. Galvanism and acupuncture are worthy of consideration.

Aneurism of the external carotid, from the shortness of this vessel, rarely occurs without involving as well the upper portion of the common artery at its division. The tumor will be found under the angle of the jaw about level with the cricoid cartilage. Paralysis of the tongue on that side and aphonia and dysphagia have been met with.

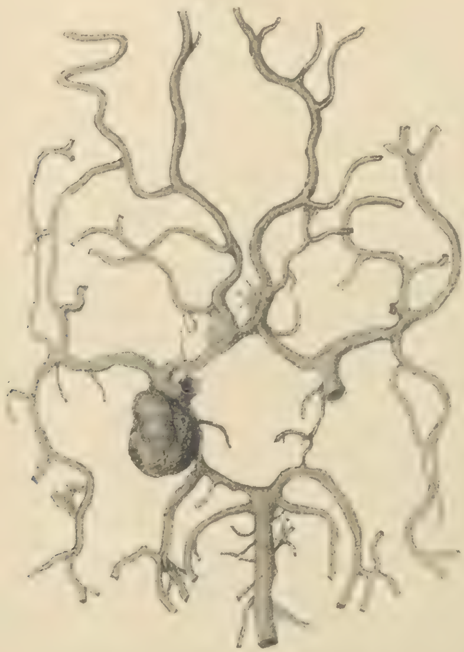
Ligation of the common carotid, or the external on its proximal side, is likely to be followed with failure on account of the extent of anastomosing vessels. Morris advised as well ligation of the principal branches of the external on the distal side of the tumor—an exceedingly difficult measure. Digital compression, galvanism, or acupuncture may be successful.

Aneurism of the internal carotid external to the skull presents but little difference from it at the point of bifurcation or the upper part of the external, the tendency being to extend inward toward the pharynx rather than outwardly.

If digital compression, medical treatment, and other milder means fail in giving relief, ligation of the common carotid, although extremely unfavorable, may be resorted to.

Intracranial aneurisms are usually formed by dilatation of the whole calibre of the artery rather than a saccular development. Pressure-effects upon the soft and yielding brain-tissue show themselves prior to giving way of the bony encasement. The symptoms are quite equivocal: an aneurism of large size may exist at the base of the brain without any symptoms whatever. "The most reliable" symptoms,

Fig. 235.



Aneurism of right internal carotid (Peacock).

according to Gross, "are apoplexy and hemiplegia, buzzing noises in the ears, deafness, dizziness, vertigo, and pain in the head, circumscribed or diffused, intermittent or continued, increased by motion, and accompanied by peculiar morbid sensations," coming on suddenly without premonition or arising gradually and imperceptibly. A loud rough or whizzing noise, heard by the patient on one side of the head and by auscultation, has in a few instances served for diagnosis.

Operative measures are limited to ligation of the carotid when diagnosis is satisfactory.

Intraorbital aneurism frequently first manifests itself by a loud snap or crack felt in the orbit or head as if something had given way. Congestion of the conjunctiva, difficulty in opening the eyelids, a feeling of tension or pain in the orbit, a loud whizzing noise, increased on stooping or lying down, more or less exophthalmos, and pulsation of a throb-

bing character, with loud whizzing bruit, may serve to distinguish this affection.

If digital compression should fail to relieve, ligation of the common carotid should be resorted to, the exigencies of the case and clearness of diagnosis justifying it.

Aneurism of the vertebral artery is of extremely rare occurrence, and the symptoms quite obscure, a pulsating tumor situated in the course of the vessel, not commanded by pressure on the lower part of the carotid, being somewhat distinctive.

If pressure, etc. fail to cure, ligation of the artery near its origin is the only resource.

Aneurism of the Abdominal Aorta.—Pulsation is more distinct than in thoracic aneurism: pressure-effects are less marked, from the yielding character of the abdominal viscera and walls. The tumor is immovably fixed, dull on percussion, and gradually increases in size and firmness with its age. The pain, at first slight, gradually becomes more severe, especially in the vicinity of the cœliac, solar, and hypogastric plexuses, and may be quite neuralgic—pain of a boring nature, burning, more fixed and attended with sympathetic disturbance when the vertebræ are involved. It must be discriminated from solid or other growths of the pancreas, malignant and other growths of the omentum, stomach, colon, or mesentery, hydatids of the liver, intestinal concretions, indurated fæces, abscesses of the abdominal walls, and abnormal pulsations of the aorta from anæmia, neuralgia, or inflammatory reaction. With the bowels thoroughly emptied and abdomen relaxed, examination in the recumbent position on a firm table, and also with the patient placed on the hands and knees, if carefully done, may serve for diagnosis, especially if the expansile character and distinct bruit over the inferior dorsal or lower lumbar vertebræ or the tumor direct is present.

Although ligation has been resorted to, it is out of the question, and our reliance is entirely on therapeutic measures, with or without compression, in the latter event anæsthesia for several hours being essential.

Aneurisms of the hepatic, gastro-epiploic, and mesenteric arteries are extremely rare, yet it is important to make a correct diagnosis to at least prevent erroneous measures of treatment. In aneurism of the hepatic artery the tumor is fixed, and in the two latter forms more or less movable from side to side, the pulsation being maintained. The latter are usually circumscribed and more or less globular, and may be accompanied by bruit. From pressure upon the liver or gall-bladder jaundice may occur, and pressure on the pancreas may result in phenomena of imperfect digestion, pain, eructation, flatulence, and vomiting; in some instances hæmatemesis existed.

Inguinal Aneurism.—Aneurism of the common iliac is extremely rare, it being much more likely to develop from the external iliac or upper part of the femoral. It is usually circumscribed, though sometimes tubular, rarely diffused. When first noticed it is small, soft, and compressible, attended with pulsation and bruit and but little pain or tenderness. It rapidly enlarges, and may seem lobulated from constriction by the fascia under which it lies. Increasing in size, œdema of the limb will arise from pressure on the saphena and femoral veins, and pain occasionally in the thigh and leg from pressure on the anterior

crural nerve. Pulsating tumors of bone must be excluded by careful examination. In no case should thorough treatment by pressure, etc. be omitted; and in the event that the external iliac or the common iliac can be reached above the sac, ligation may be attempted. If Syme's procedure, after the "old method," is deemed advisable, firm pressure on the abdominal aorta during the operation should not be neglected.

FIG. 236.

Sacculated aneurism of femoral artery (Parmenter).

Aneurism of the profunda femoris is only likely to be mistaken for pulsating tumor of the femur. If compression carefully applied does not succeed, the surgeon must use his discretion whether ligation of the external iliac or the common femoral is most suitable.

Aneurism of the superficial femoral and popliteal presents no special clinical features, and the suggestions made in the general considerations of treatment do not here need repetition, more than the brief mention in the following order of preference: compression, digital, by flexion, or instrumental, and the Hunterian method of ligation. In diffused popliteal aneurism amputation may be a question for consideration.

Aneurisms of the leg and foot are somewhat rare, and do not require special consideration; their diagnosis and method of treatment will be readily suggested by what has heretofore been submitted.

Aneurisms of the Internal Iliac Artery and its Branches.—Erichsen has only recorded one instance of aneurism of the internal iliac and one of the pudic, so rarely have these vessels been involved. Gluteal and sciatic aneurisms, both traumatic and idiopathic, have occasionally been observed, the former more frequently than the latter. Erichsen says that "gluteal aneurism has generally been found situated at the upper part of the great sciatic notch, but may extend over a large portion of the buttocks. Sciatic aneurism lies more deeply, and a portion of the sac may be within the pelvis." They vary in size from a slight swelling to a tumor as large as a child's head—are accompanied by strong pulsation, whirring and buzzing murmurs, sciatic pain, and possibly local paralysis.

The DIAGNOSIS is somewhat difficult, and abscess, soft sarcomata, cysts, and sciatic hernia must be eliminated.

Various methods of TREATMENT have been suggested, as opening the

sac and ligation of the vessels, ligation of the internal iliac, injection of coagulating fluids, or galvano-puncture. Pressure on the cardiac side of the tumor is impossible.

Cirsoid aneurism (*vide* Chapter I. Vol. II.) and **angioma** present clinical features that are quite definitive, yet the treatment is in many cases unsatisfactory. If detected early and while small, thorough removal by incision, the lines of incision being carried wide of the tumor, or the thermo- or galvano-cautery, should be resorted to. In other instances the ligation of the afferent vessels may succeed; the injection of coagulating fluids after the method of Broca, who used perchloride of iron, preventing the passage of the styptic beyond the desired area by pressure with a leaden ring, attacking the tumor in sections by dividing it into lobes by means of rubber tubes; or the nitrate of silver, as suggested by Bigelow; coagulation by electro-puncture or ligation of the main vessel. Two or more of these methods may be combined.

CHAPTER XXXIII.

INJURIES AND DISEASES OF THE JOINTS AND JOINT STRUCTURES.

By Joseph Ransohoff, M. D.

General Considerations.

There enter into the formation of every joint two or more bones held together by a capsule which is strengthened by ligaments. Within there is contained a quantity of synovial fluid sufficient only for the lubrication of the joint-surfaces. Even in so large a joint as the knee it does not normally exceed two or three cubic centimetres. Joint and capsule are supplied by blood-vessels and by sensory nerves. The latter are always derived from a source *common to the supply of the muscles which act upon the joint.* The synovial membrane covers only the capsule. The articular ends of the bones are smooth, covered with cartilage, and supply none of the synovial fluid. Within the joints that are most subject to pressure, to violent concussion, and to frequent movements there are *fibro-cartilages*, which by their borders are attached to the capsule, thereby affording the joint additional strength, reducing shock, and increasing the range of movements. Such cartilages are found in the temporo-maxillary articulation, the acromio-clavicular, the wrist- and the knee-joints. To the outer side of the joints, but often connecting with them, there are found *bursæ*, which play an important rôle in the gliding of the tendons over the joints, and are often significant in the injuries and diseases of the joints proper. The capsule of the joint, made up of strong fibrous tissue, is capable of resisting great pressure without rupture. *Rupture of the capsule* can only occur from direct violence or in consequence of degenerative changes incident to disease. In the distention of the capsule a separation of the articular ends of the bones does not ordinarily ensue. The *position of a limb* depends somewhat, but not altgether, upon the degree of distention of the joint with fluid. Experimental distention of a joint invariably causes it to assume a position midway between flexion and extension. In inflammatory conditions, chronic in character, this position is maintained uniformly, not owing to the distention of the joint by fluid, but because of the greater strength of the flexor muscles over the extensors, and the proneness of the latter to atrophy more quickly than the former. In *hemorrhage* into a joint or acute distention thereof by serous exudation the limb is often maintained in the extended position. The synovial membrane, being of the nature of a serous tunic, reacts rapidly to irritation, to the presence of foreign bodies, to injury, or to effusion of blood. The entrance of *blood* into a joint is of significance, since every injury to the joint may be associated with more or less hæmarthrosis. When small quantities of blood are introduced into a joint, becoming mingled with the synovial fluid, coagulation does not ensue: even when large effusions of blood result, as in the knee, coagulation of the *entire* effusion never takes place. Some coagula will be deposited upon the articular surfaces, become imbedded in an endothelial layer proliferated from the normal synovial covering, and in the course of time undergo organization. The greater quantity of the coagula will, by very slow process, often continuing through months, remain floating within the fluid substratum and ultimately undergo absorption.

Injuries of Joints.

Contusion.—The simplest injury to a joint is the contusion resulting usually from direct violence, such as a fall or a blow. Very rarely,

as in the case of the small joints of the hand and wrist, is it the result of indirect violence. When severe, contusion often makes itself manifest by hemorrhages into the periarticular tissues, which may, in the course of twenty-four hours, permeate the subcutaneous layer and appear in the form of ecchymoses of greater or less extent. In the severer forms of contusion considerable hemorrhage into the interior of the joint takes place. *Swelling* of greater or less extent, with loss of the normal joint outline, will make easy the recognition of the condition. *Pain*, as a rule, is not very severe, the inconvenience of the joint movement and tenderness on pressure being the only subjective symptoms complained of. In extensive hemorrhages into the joint slight rise of temperature may result during the first twenty-four or forty-eight hours.

The TREATMENT of contusions consists of rest, evenly applied bandages, and elastic compression. If much pain be complained of, applications of ice during the first twenty-four or forty-eight hours will often give great relief. After the lapse of two or three days passive movements should be made and systematic massage of the joint practised.

Sprain.—A sprain is always the result of indirect violence, and is produced when *the movements of a joint are carried beyond their physiological limits, but stop short of a permanent displacement of the articular ends*—that is, dislocation. A sprain may thus be said to be the prodromal stage of a dislocation. Excessive muscular action may likewise produce a sprain. In many individuals the presence of a sprain predisposes to recurrence of the condition from apparently trivial causes. In the majority of sprains there is a stretching of the capsule and of one or more of the ligaments. In severe cases there is a rupture of one or both of these, with consequent laceration of blood-vessels, and often nerves. *Hemorrhage* into the joint and the periarticular structures is almost always present. The ligaments, as a rule, if torn, give way at the point of insertion rather than in their continuity. This is made manifest in milder cases, not by tenderness to pressure over the articular line, but at some point above or below, corresponding to the point from which the ligament was torn. In the *tearing of a ligament* from its osseous attachment particles of bone are not infrequently brought away with the detached fibrous structure. In severe cases the bone may be denuded of its periosteum for a considerable distance.

In the sprains of childhood and adolescence this condition, owing to the greater flexibility of the bone, is not uncommon. In adults, on the other hand, the extreme limit of the sprain is the tearing away of a greater or less fragment of *bone* to which the ligament, placed upon the stretch by the trauma, has been attached. It is in this way that fractures of the lower end of the radius and of the lower end of the fibula may be considered as severe forms of articular distortion. They are sometimes known as *sprain-fractures*. In severe sprains the segment of capsule *opposite* that which is put upon the stretch may be pinched between the articular surfaces, which are by the sprain more closely approximated to each other than normally. It is in this way that in severe sprains of the ankle pain is felt on both sides of the foot. In very severe cases a rupture of the muscles surrounding the joint may ensue. This, however, is quite uncommon. When it results, the muscle gives way along the line of its attachment to the tendon.

The SYMPTOMS of a sprain are—pain, swelling, ecchymosis, and limitation of joint function. The pain at the moment of accident is

often very severe, leading at times to syncope. When an examination of the joint is made the tenderness will be found most marked over the *articular line* and over the *insertion of the ruptured ligament*. The swelling varies greatly in different cases, since it depends upon the hemorrhage within and about the joint. In mild cases it is limited to the periarticular structures, appearing in the form of ecchymoses within the course of two or three days. The ecchymoses, owing to ruptures of muscles, are often found at points considerably removed from the affected joint. The ecchymosis following a sprain is often found at a distance far removed from the joint without rupture of muscle. Often the only ecchymoses seen in sprains of the shoulder appear after the lapse, sometimes, of many days at the point of insertion of the deltoid. As a rule, the swelling attains its maximum within the course of twenty-four hours. In many cases, however, the hemorrhage into the joint produces a *reactional hydrarthrosis*, which reaches its maximum in from a week to ten days. The degree of periarticular or intra-articular swelling depends entirely upon the extent of damage done to the ligaments and the joint-capsule.

The frequency with which joints are subject to sprain varies with their nature. The *enarthrodial* joints, in which the range of movement is widest, are least subject to sprains. On the other hand, joints of the hinge variety are more frequently the seat of such lesions. Sprains occur, therefore, most often in the ankle, the knee, the wrist, and the small joints of the hand.

The CLINICAL HISTORY of a sprain varies with the conditions produced by it. In some cases, characterized by the stretching of the ligaments without laceration, the pain and swelling speedily subside, and after a few days or a week the joint-functions are restored. In severer cases, where hemorrhage into the joint and periarticular swelling indicate extensive laceration, the progress toward recovery is often very tedious, and months may pass before a final restitution to the normal condition takes place. In the *severest cases* circumscribed *tender areas*, *thickening* of the *joint-capsules*, or *chronic hydrarthrosis* may leave the joint permanently impaired. *Atrophy of the muscles* is often found to follow upon severe sprain during the first two weeks, and is the result of the injury to the articular nerve-filaments. This condition is often irreparable.

Extensive hemorrhage into a joint is always significant of a tedious recovery, and frequently renders unfavorable the prognosis, so far as complete restoration of joint function is concerned. In subjects with a tendency to diathetic, and particularly to tubercular, disease a sprain is often the exciting cause of chronic joint disease.

TREATMENT.—In the treatment of sprains *absolute rest* should be at once secured. Elevation and suspension of the affected limb at a right angle will often relieve the pain at once. This position conduces to the arrest of hemorrhage and, by rapidly depleting the veins, facilitates the absorption of the already effused blood. To further hasten absorption *compression* by an elastic bandage may be considered as of prime importance in the treatment of sprains. *Cold applications* are often of value for the relief of pain. To these may be added the lead and opium wash, or a solution of chloride of ammonium and opium, or an ichthyol ointment. Internal administration of opiates may become necessary when pain cannot be

otherwise alleviated. To secure absolute rest *immobilization of the joint* by means of plaster-of-Paris, starch, or silicate-of-sodium bandages is often indicated. The indiscriminate use of fixed dressings must, however, be condemned, since their unnecessarily prolonged use may lead to irremediable stiffness of the joint. It is preferable to resort to the use of splints, which can be removed daily if required. After the subsidence of the acute symptoms of the sprain the main object of treatment must be that of the *restoration of joint function*. Efforts in this direction should never be delayed beyond the second week. The chief agents in attaining this end are *passive movements* and *massage* methodically applied. In the severest forms of sprains, in which the intra-articular effusion is not absorbed by this treatment, recourse must be had to aspiration of the joint.

In sprains which are not relieved by one or other of these methods of treatment, singly or combined, counter-irritation by means of *blisters*, or, preferably, by *ignipuncture*, often answers admirably. When there is any thickening under an especially tender point recourse should be had to free incision. In a few cases hemorrhagic cysts have been drained or granulation masses removed with a curette, thereby permanently relieving the symptoms. The writer recently drained with success such a subfascial cyst as large as a hazelnut. It was over the trochanter, and directly under a point which had been extremely tender during two years following a sprain of the hip.

Penetrating Wounds.—The injuries of joints hitherto considered may prove serious to the function of a limb, but being subcutaneous they never, *per se*, jeopardize either limb or life. In strong contrast to these, therefore, are the wounds in which communication is established between the external air and the joint interior. Penetrating wounds, particularly of the larger joints, like the knee, the hip, the shoulder, and the ankle, may and often do become among the gravest of the injuries to which the body is subject that are not immediately fatal.

The gravity of penetrating joint wounds depends not upon the mere opening of the synovial membrane, but on the introduction into the serous cavity at the time the wound is inflicted or subsequently of morbific matter, which in many cases produces a *septic inflammation*, always dangerous to limb and often to life. That the mere penetration of a joint is free of danger is displayed daily in the operating-room. Aspiration, puncturing with a trocar, free incision for the removal of foreign bodies, with the proper precautions as to asepticism, involve no danger. A wound of the synovial membrane heals by primary union as does a wound of the skin. The *great danger of infection* of a joint from a penetrating wound lies in the complicated construction of many of the joints, the difficulty in securing adequate drainage, the communication normally present between the joint and surrounding bursæ, and the ease with which the connective-tissue planes about the joint are involved in the diseased process.

Penetrating wounds of the joint may be divided into the *incised*, the *punctured*, the *lacerated*, and the *gunshot* injuries. In very many instances the wound is complicated with more or less extensive injury to the surrounding structures, particularly the bones, the larger blood-vessels, and the nerve-trunks. For practical purposes simple incised wounds may be differentiated from the complicated forms, for in the latter the opening of the serous cavity is less significant than the concomitant injury to bone, blood-vessel, or nerve. In civil practice the injuries most frequently seen are of the punctured or incised variety. The shoemaker thrusts an awl into his knee or the woodman sinks his axe into ankle or knee; the mechanic occasionally thrusts a pointed

instrument into the wrist-joint. The *wound of communication*, it will therefore be seen, varies very much in its size, being often so small as to be just perceptible, or large enough, on the other hand, to afford a view of the joint interior. In the latter instance the diagnosis is, of course, simple; in the former, on the other hand, it may be difficult to recognize the penetrating nature of the injury, and often it is impossible.

SYMPTOMS.—Cardinal signs indicative of penetrating joint injury have been said to be the *outflow of synovial fluid*, pure or mixed with blood, and in the absence of this the rapid *filling* up of the joint-cavity with *blood*. *Neither* of these signs is pathognomonic. The opening of a periarticular bursa or of a tendon-sheath will permit the outflow of a fluid closely allied to the synovial. When the perforation is small the opening in the joint closes, and will allow no permeation of fluid through the wound tract. The *accumulation of fluid within the joint*, on the other hand, will often attend contusion of the joint without perforation. It is not uncommon, for example, to find, in consequence of falls upon the knee, a contused and lacerated wound of the periarticular structures, followed by hæmarthrosis without penetration of the joint.

In compound fractures of the epiphyses joint penetration may often be suspected, but is rarely subject to demonstration until, in neglected or badly treated cases, the joint reacts to septic infection. When the diagnosis cannot be otherwise established, the careful use of a sterilized probe may bring certainty. In small punctured wounds the displacement of the tract between muscles and tendon-sheaths will often render the search futile. If indications arise demanding a positive diagnosis, an enlargement of the wound under anæsthesia and exploration of its course must be made as the preliminary step of the proper operative treatment.

Punctured and small incised wounds of even the largest joints are not, as a rule, attended by severe constitutional disturbance. A man with a punctured knee may follow his vocation for a day or two without any marked local or general disturbance. In the *lacerated wounds*, on the other hand, there is, as a rule, very great *depression*. Being often associated with fracture or dislocation and accompanied by profuse bleeding, the shock manifested is often extreme.

The CLINICAL COURSE of these injuries depends wholly on the presence or absence of primary wound infection. In the latter even large wounds heal *per primam* without local or general reaction. The continued outflow of synovia for several days, while it jeopardizes so fortunate a result, does not annul it.

In the presence of infection the course will be determined, to a large degree, by the nature of the infection, the facility for drainage, and the treatment instituted. The introduction of the less virulent pus-formers into punctured wounds may be followed by a period of quiescence varying from two days to a week. The vascularization of the synovial tunic is then made evident by a serous articular effusion, which speedily becomes turbid and contains flakes of lymph. The joint and periarticular tissues become reddened, disfigured, painful, and tender. Often a chill announces the inception of the suppurative process. In evidence of systemic toxicæmia there is a continuous fever with morning remissions, which continues while intra-articular pus-retention exists. In these milder forms of traumatic synovitis, if ample opportunity for drainage is afforded, the integrity of the joint may still, to a large extent, be maintained. The outflow of the pus through one or more openings reduces the intra-articular tension, the discharge in the course

of a few weeks becomes reduced to a minimum, the cartilaginous covering may even be left intact, and the joint saved with a fair degree of function.

In the cases of *grave infection*, with insufficient drainage, the joint structures soon undergo changes that place them beyond repair. The synovial membrane becomes greatly thickened, the surrounding ligaments become softened, the cartilage covering the bones raised at first in areas, then separated altogether from the underlying bone. The joint structures thus become almost altogether unrecognizable. Communications are established between the pus-cavity into which the joint has been converted and the bursæ originally communicating with the joint tendon-sheaths overlying them. In this way a *joint abscess finds its way to the surface*, often in as many as from three to six places removed from each other by considerable distances. While this process in and about the joint is going on the *limb* becomes often enormously *swollen*, the general septic manifestations are very marked, and, unless relief is afforded, death may sooner or later occur. But even in such unfortunate cases life and limb are often preserved after protracted suppuration, lasting at times for many months.

As in wounds of the soft part, those of joints that are primarily infected with the more malignant pus-formers (the *streptococcus infection*), if left to themselves, often run a more rapidly fatal course. From the very beginning the general manifestations of sepsis are graver. Within twenty-four hours of the injury the joint is already enormously tumefied. Within forty-eight hours the discharges are slightly putrid, and often an examination of the joint reveals free gases in the interior. In these cases ascending phlebitis of the deeper veins often leads to rapidly spreading gangrene of the extremity. In one case, seen by the writer, of a wound of the knee with such grave primary infection gangrene had developed within twenty-four hours; within thirty hours the gangrene had spread to the hip, ending fatally within thirty-three hours from the infliction of the injury. Between these extremes in the clinical course of penetrating wounds of the larger joints there are all degrees in rapidity and virulence of symptoms consequent on infection.

In penetrating wounds of the smaller joints, particularly of the hand and foot, owing to their greater simplicity the local and general manifestations are proportionate to the size of the joint injured. Whereas, as a rule, the function of the joint involved is permanently restricted, the infection remains localized and limited, and life is rarely threatened. But even in this regard caution in prognostication is essential, since the extension of disease to parts far removed from the primary injury occasionally ensues.

The TREATMENT of *penetrating wounds* of the joint must have for its objects—first, the *securing of primary union* through the prevention of infection; and, second, the treatment of the traumatic arthritis when the infection has already taken place. To meet the first condition is simple when the diagnosis is clear. Like wounds in other parts, joint wounds must be thoroughly cleansed. Unevennesses of the surface and contused edges must be removed by clean incisions, and the joint should be thoroughly explored for parts of the vulnerating body which have possibly remained imbedded in it. To accomplish this the wound into the joint may without fear be very much enlarged. The joint-cavity is then to be thoroughly irrigated with a sublimate solution of 1 : 1000. If there has been much oozing, a silkworm-gut strand may be left for

drainage. The wound is closed by sutures and the joint, being aseptically dressed, kept at rest.

When the diagnosis of *joint penetration is in doubt*, the treatment should depend largely upon the facilities for aseptic exploration at the command of the surgeon. Without such facilities it is probably wiser to await the development of symptoms indicative of infection before resorting to operative interference. When the surgeon has control of his surroundings it is advisable, as in cases of doubt pertaining to penetrating wounds of the abdomen, to *enlarge* the punctured or incised *wound*, to trace it to the joint-capsule, and, if this be found to be penetrated, to treat it as in the cases just considered. With the first *evidences of septic infection*, in either class of cases, the treatment must consist of the antiseptic management of the joint interior. By this is meant a free incision for the removal, through drainage, of the contents of the diseased joint and antiseptic irrigation of the joint interior. In proportion as these objects are sought early or late the integrity of the joint will be more or less maintained or entirely lost. For the drainage of joints that are *already suppurating*, nothing excels rubber drainage-tubes of considerable calibre.

These tubes ought not be drawn directly through the joints between the bony surfaces, since the latter would by pressure make thorough drainage impossible, and the pressure upon the cartilage by the tube would, perforce, if long continued, produce a localized pressure-necrosis. Irrigation in these cases must usually be made at least once, and often twice, in twenty-four hours, until suppuration is very materially diminished. With subsidence of the joint distention, the reduction of periarticular inflammation, and of purulent discharge the frequency of the irrigation may be lessened. The drainage-tubes should not often be removed, at least in the early history of the case, since their return might be rendered difficult through the retraction of the aperture in the fibrous capsule. As the case progresses toward recovery they should from time to time be removed and shortened as occasion requires.

In the management of *traumatic suppurative arthritis* regard must be had to the position of the limb with a view to probable future *ankylosis*. Left to itself, a suppurative arthritis of the knee will invariably leave the limb much flexed; of the elbow, the arm slightly so. An early regard for the position to be attained is therefore an essential element of treatment.

When the penetrating wound of a joint is only one feature of a complicated trauma, the question of *primary excision*, or even of *amputation*, may arise. For uncomplicated wounds of the joint neither of these operations is primarily indicated. In cases of *compound dislocation* with fracture into the epiphysis, particularly in the upper extremity, a primary excision will often save a useful limb. The same is true of compound dislocations of the ankle. In compound dislocations of the knee the force producing it is necessarily so great as to make the joint injury of secondary importance. In these cases primary amputation must, as a rule, be resorted to.

Gunshot Injuries.

Gunshot wounds of the joints are always *lacerated* and *contused*, and for this reason alone afford a better soil for infection. In the wounds made by larger missiles there is always added considerable injury to the

epiphyseal ends of one or both of the contiguous bones. In these wounds the *epiphyses* are often shattered beyond repair, and the larger vascular or nerve trunks are often involved to a degree calling for immediate amputation. A gunshot wound of a larger joint by *a ball of large calibre*, when left to itself, often pursues a rapidly fatal course. Of 271 joint injuries in the Russo-Turkish war, tabulated by Reyher, 146 proved fatal; mortality, 54 per cent. From the very first day the joint becomes tender, the slightest movement giving rise to excruciating pain. The integuments become discolored, the veins are distended, and gas-formation in and about the joint rapidly takes place. The constitutional symptoms accord with the degree of the local infection: the temperature ranges between 103° and 105° F., the sensorium becomes obtunded, delirium develops, and the patient, if unrelieved, often dies, in from three to five days, of acute septicæmia. In the gunshot wounds of joints made by *small-arms*, as seen in civil practice, the symptoms are far less pronounced. They accord with those described of the milder infected wounds that are penetrating from other sources, but even in these, owing to the damage done to contiguous bones and the presence of foreign substances, the symptoms develop more rapidly. In wounds produced by the larger missiles fired from modern arms there is usually perforation, under which circumstances, as in gunshot injuries elsewhere, the wound of entrance is smaller than that of exit and has a tendency to contract. The wound of exit is larger, often gaping, and on exploration presents detached spiculæ of bone. In wounds made by missiles of small calibre perforation of the larger joints is not common. The missile may rarely be found loose between the joint surfaces. Often it is found firmly imbedded in the epiphysis after having produced more or less splintering.

The DIAGNOSIS OF GUNSHOT INJURIES of the joints by larger missiles is always simple. The probe, or preferably the finger, thoroughly sterilized, can be made to freely enter the joint-cavity and detect the damage done. In the injuries produced by balls of small calibre the diagnosis is likewise, as a rule, easily made. The outflow of synovia mixed with blood, the rapid filling of the joint with fluid, the crepitus detected by manipulation, the impairment of joint motion due to the presence of the missile or fragments of bone, make the diagnosis clear. There are, however, cases in which doubt must obtain, as in the cases of other than gunshot wounds in the vicinity of joints. In doubtful cases nothing but an *exploratory incision* will lead to positive diagnosis. This should always be done, except in wounds made by the smallest-calibre revolvers or rifles. These ordinarily do little damage, the force propelling being slight, and they rarely carry before them particles of infected clothing: if left to themselves, primary union or healing under a blood-clot ensues, as in similar wounds of the soft parts. In wounds by larger missiles, even those from large revolvers, the source of wound-contamination is chiefly in *particles of clothing* penetrating with the ball. The latter as it comes from the manufacturer has been shown to be almost sterile; the temperature to which it is raised in its course and by impact is insufficient to sterilize the foreign substance which it carries into the wound before it. In three out of five pistol-shot wounds of the knee recently recorded particles of clothing were found in the track of the wound.

Wounds of the joint made by the *larger projectiles of war*, propelled with great force, and particularly those of modern pattern, are almost always perforating.

In joints with subtendinous pouches, like the elbow and the knee, joint penetration not infrequently occurs without injury to the bone. A similar penetration may occur, for example, from a wound in the antero-posterior axis of the knee without injury to bone when the leg is flexed at an angle of about 140° against the thigh.

TREATMENT.—*The course of a wound is mapped out by the hands of him who first sees it. This is particularly true of gunshot wounds of joints.* Except when profuse hemorrhage calls for immediate care the first attention should be *limited* to the application of an *antiseptic dressing.* More should not be done until the best possible facilities are afforded for antiseptic and aseptic manipulations. Above all things, *probing with finger or instrument can only be harmful* unless every precaution toward surgical cleanliness is observed. Conservatism in the sense of antisepsis and immobilization is indicated in cases of smaller wounds, such as are seen in civil practice. In all other *gunshot injuries of joints conservatism is probably most favored by primary operative treatment.* Delay until the manifestations of infection compel a tardy interference entails disaster to life and limb more often than in joint wounds from other causes. This has been established beyond a reasonable doubt.

Of 46 gunshot injuries of the larger joints treated antiseptically primarily, 6 ended in death; mortality, 13 per cent. This primary treatment included antiseptic occlusion, immediate drainage, and primary excision. In 78 cases treated by antiseptic means after infection had occurred the mortality was 54 per cent. (Reyher).

According to the varying conditions found, recourse must be had to *exploration* and *lavage* of the joint, *atypical excision*, or *amputation.* In civil practice the latter would rarely be demanded; even in military practice it will probably be reserved for the complicated injuries, of which the joint penetration is only one element. Extensive injury to to the soft parts, comminution of both epiphyses and fracture extending into the diaphysis, injury to larger nerve and vascular trunks, are the conditions demanding primary amputation. As for severe injuries from other causes, amputations of the lower extremity, other things being equal, will be oftener demanded than those of the upper. In the smaller wounds seen in civil life, when the diagnosis is clear the facilities for asepticism should determine the course; without them, an expectant treatment limited to thorough cleansing of the wound and immobilization should be trusted to rather than exploration.

With facilities for aseptic work at hand even the smaller wounds seen in civil life should be subjected to immediate exploration. The wound should be enlarged and the site of joint penetration thoroughly exposed. When it is required for further manipulation a free incision into the capsule must be made. With the parts so exposed the course of the ball can ordinarily be easily followed. If it has ploughed its way into an epiphysis, the canal should be enlarged with chisel and sharp spoon until it is found and dislodged. Loose spiculæ of bone are to be removed with the forceps and uneven projections chiselled away. An *atypical resec-*

tion may thus be made. Particular care must be given to the *removal of foreign substances* carried in with the missile. If in perforating wounds the manipulations have brought the operator near the distal side of the joint, a counter-opening should here be made. Ample facility for drainage is the condition on which success depends. After such atypical resection fair joint motion is often retained. If both epiphyses are injured, it is probably wiser to make a formal excision with the view to obtaining ankylosis.

The suggestions here made for the early operative treatment of gunshot injuries tend toward an ideal which is within reach in civil practice. The statistics of our Civil War and of the Continental wars of 1866, 1870, and 1877 speak strongly in favor of non-interference in gunshot injuries of the larger joints. These statistics belong to the preantiseptic period of surgery, and are of historical value only. It is probable that with the increased facilities for surgical cleanliness on the field and, above all things, in military hospitals, the danger of wound infection following operative interference will be greatly reduced, although never, probably, for reasons that are apparent, to the degree that it has been in well-appointed civil hospitals.

Diseases of Joints.

Diseases of joints which result from irritation or infection may be divided into the *acute* and the *chronic*. The division can also be made according to their *primary* or *secondary* development, and, finally, according to the end-product of the process into the *serous* or *purulent* on the one hand, and the *dry* or *plastic* on the other. Exact differentiation between the various types is often a matter of considerable difficulty. As elsewhere, an acute disease of a joint often retrogrades slowly, becomes the subject of exacerbations, and eventuates in a chronic disorder.

In point of pathology, differentiation is also at times difficult. As in cases of pleurisy with effusion it is at times impossible to state just when the serous becomes converted into a purulent exudate, so in inflammatory or subinflammatory diseases of the joint the differentiation is often impossible. Furthermore, as in the intrathoracic disease just referred to, the disappearance of the serous effusion will leave a *fibro-plastic material* as the only vestige of pre-existing disease, or, as we may have a fibro-plastic disease of the pleura unchanged at any time, so we may have inflammatory diseases of the joint converted from the serous into the plastic, or one that remains plastic throughout the entire course of the disease. Again, as elsewhere, differentiation between lesions of the joints that are purely the result of *irritation*—mechanical, as from *injury*, *chemical*, as from a deposit of *uric-acid salts*—or the purely *infective* is difficult to make. For practical purposes, therefore, the best division possible of acute diseases of joint structures under the circumstances given is into—

(*a*) *The simple serous synovitis.*
(*b*) *The simple purulent synovitis.*
(*c*) *The dry synovitis.*
(*d*) *Acute suppurative arthritis.*

Simple Synovitis with Effusion.—Acute serous synovitis is the commonest form of joint disease. As a rule, it is the result of a contusion, but may arise without any known cause. In point of frequency

the joints involved are the knee, the elbow, and the ankle. Among the joints less frequently involved are the hip, the shoulder, and the small joints of the extremities. The pathology of the disease is limited to changes in the synovial membrane in which the usual manifestations of irritation and inflammation develop according to the cause producing the disease.

When this affection is the result of an irritation such as is produced by a trauma, the presence of a blood-clot, the pinching of the synovial folds, or irritation from chemical causes, such as occur in gout and in some cases of gonorrhœa, there is a congestion of the synovial membrane, the vessels are injected, the entire surface reddened, particularly about the line of attachment to the articular cartilages. These undergo no change, and by their pearliness are therefore in strong contrast to the reddened synovial surfaces. From these there is effused at first an increased quantity of synovia, and soon the exudate becomes closely allied to the serous effusion found elsewhere. Clear at first, it has a tendency to become turbid from the admixture of disintegrated epithelial cells and of leucocytes. The turbidity is often increased by the presence of blood-disks from minute hemorrhages into the joint-cavity. Within the exuded fluid flocculi of fibrin in greater or less abundance are usually found. These may be attached to the synovial fringes and to the more dependent portions of the joint, or they may be floating about in the free exudate.

In mild cases of synovitis the condition described lasts from a week to ten days, when, by the gradual absorption of the exudate and the return of the distended vessels to their natural condition, the joint resumes its normal appearance and function. In other cases absorption goes on very slowly, or it may altogether fail to take place, under which circumstances we have established the condition known as hydrarthrosis, the chief feature of which is the effusion into the joint.

Simple Purulent Synovitis (*Synovitis Catarrhalis Purulenta*).—In less favorable cases or in consequence of improper management the exudation increases often to enormous proportions. Its character may also change: turbid at first from the admixture of few cellular elements, these increase until the exudate assumes a purulent character. The rapidity with which the effusion becomes purulent is at times so great that the synovitis in these cases seems to be purulent from the beginning. Except for the latter, the condition of the joint interior does not vary at first in the simple purulent form of synovitis from the serous.

Particularly in children, as Volkmann and Krause have shown, there may be a purulent effusion into the joint without destruction of the articular surfaces or permanent impairment of synovial membrane, joint-capsule, or ligaments, provided spontaneous perforation occurs or an early outlet be made for the discharge.

Dry Synovitis.—In certain cases of acute synovitis the fluid exuded may be very small in quantity or altogether absent. In proportion the flakes of fibrin are greatly increased, until they may appear as a continuous layer covering the articular surfaces and forming a deposit of varying thickness on the synovial membrane and cartilages. The fibrin thus thrown out shows remarkable tendency toward organization. The smooth, glistening character of the serous surfaces is lost. In its place there are masses of fibrin, often unevenly disposed and by joint movement often drawn into shreds of unequal length and adherent at one or both ends. If ankylosis do not occur, these shreds may speedily become detached and present themselves in the form of many small

bodies the size of a pea or bean, round or ovoid, and consisting of concentric rings of fibrin—*rice-bodies*. In other cases the joint surfaces are speedily welded together by the organization of the exuded lymph. *Ankylosis* may sometimes follow these acute dry synovitides with remarkable rapidity.

Acute Suppurative Arthritis.—The conditions above described are superficial, and do not involve, even if long continued, the integrity of the joint structures. Acute suppurative arthritis, however, being always an evidence of grave infection, is almost from the first *destructive* in its tendency. Although in the beginning the lesions are limited to the synovial membrane and the product may be but a serous effusion, there soon follows purulent distention of the joint. In addition to the synovial lining the cartilages participate in the morbid process. They lose their pearly hue and assume a reddish or even blue tinge. Blood-vessels appear within them, and absorption, often in patches, takes place, the subjacent bone thereby becoming exposed. Shreds of cartilage are often raised in areas, become *necrotic*, and are thrown off into the joint-cavity. The ligaments become softened and permeated by small purulent foci; the joint becomes loosened and devoid of function. *Displacements of the articular ends* of the bones are therefore of early and frequent occurrence. *Caries of the articular ends*, extending for a greater or less distance into the epiphyses, results. The periarticular structures, bursæ, and tendon-sheaths take part in the suppurative process. Abscesses communicating with the joint occur and develop in different places. They are often far removed from the part primarily involved. Unless adequate treatment is instituted the destruction of the joint invariably follows. If the limb is saved, the suppurative process gradually subsides through the drainage given by fistulous formations or by surgical treatment. The joint-cavity is almost always obliterated. *Ankylosis*, fibrous or bony, is an almost inevitable result.

Symptoms.—The superficial position of most of the joints facilitates the recognition of a simple synovitis. Except in the joints deeply seated, like the shoulder and the hip, the four cardinal symptoms of inflammation can be easily recognized. In the latter joints only are we called upon to look to other than the characteristic symptoms for recognition of the condition. As has been said in the symptomatology of joint injuries, the patient first complains of pain, which, as a rule, is proportionate to the rapidity of the joint distention with fluid. Generally the *pain* is complained of *in the joint itself*. Only in exceptional cases, as in the hip, it is felt in a part far removed. With the pain there is associated more or less *tenderness*, often felt at one or more points along the articular line rather than over the entire area. In cases of traumatic origin the reason for this is apparent. In other cases Volkmann has ascribed these special points of tenderness to the deposit beneath them of fibrinous material. It is more probable, however, that these special points of tenderness correspond to the attachment of ligaments or duplicatures of the synovial membrane, which are stretched by unequal tension of the effusion in the joint when pressure is made over them. Where pain is not complained of when the limb is at rest, it will often be found to be very severe when any effort at motion, voluntary or passive, is made. The *swelling* is the most marked feature of a simple synovitis.

Often within twenty-four or forty-eight hours it is sufficiently developed to have effaced all of the normal outlines of the joint.

The grooves on both sides of the patella, the supra- and infrapatellar depressions, are often thus early effaced and distinct fluctuation manifested. The patella with a little tap of the finger can be made to strike the anterior intercondyloid depression from which it has been lifted by the serous effusion (ballottement). In the ankle the swelling is most and soonest marked below the malleoli and in front of the joint. In the elbow the grooves between the olecranon and condyles soon become obliterated, and often the swelling is marked between the head of the radius and the outer condyle. In the wrist the swelling makes itself soonest apparent beneath the styloid processes of radius and ulna, and the antero-posterior diameter of the joint becomes to the naked eye greatly increased. The effusion into the shoulder-joint, as a rule, manifests itself by a greater fulness and by increased antero-posterior measurement. Except through the axilla effusion into the joint cannot be easily mapped out, because of the thick muscular covering upon its outer anterior and posterior surfaces. For the same reason effusions into the hip are also recognized with great difficulty. Occasionally a tumefaction in front of the joint or to the outer side and behind the trochanter gives positive evidence of joint effusion, and a sensation of deep fluctuation may occasionally be obtained.

The development of an acute synovitis is very frequently, although not always, associated with definite change in the *position* of the limb. For the most part, one *midway between flexion and extension* is assumed, and maintained throughout the entire course of the disease. The knee becomes flexed upon the thigh, the foot becomes placed in the position of talipes equinus, the hip becomes flexed and abducted. When the shoulder is involved the arm is held close to the side of the body; in disease of the elbow the forearm is extended at an angle of 140°; in disease of the wrist there is a slight drop, the fingers are maintained almost in extension, and the hand somewhat flexed on the forearm. The assumption of these positions has been accounted for through the fact that by them an equal pressure on different part of the joint surface is secured, since they are positions taken by the joints when injected experimentally. This explanation does not obtain in cases of synovitis, since in some of great distention with serous fluid no faulty position is assumed. In every case of *purulent synovitis* this tendency to contracture makes itself apparent early, as it does also in cases of tubercular disease, to be hereafter considered. It is exceedingly probable, therefore, that the contracture is a reflex phenomenon manifested only when, from the nature of the disease, prolonged fixation, in the position in which extensors and flexors are equally favored, is to be maintained for a long time.

The symptoms hitherto considered are far more important than the remaining cardinal symptoms of *redness* and *heat*. In simple serous synovitis redness, as a rule, is altogether absent. In the purulent form it is present only when preparations are making toward spontaneous perforation. When synovitis is the result of joint contusion the reaction following periarticular injury is often causative of a redness far in excess of that which follows the synovitis alone. In joints superficially placed, like the elbow, the knee, and the wrist, a local elevation of temperature of from one to two degrees may usually be recognized.

The general condition in cases of simple serous synovitis is commonly not influenced by the disease. Extensive effusions may take place in the joint without other than local symptoms. This is particularly true of the synovitis which is the result of an irritation such as a primary trauma will produce. As has already

been stated, the absorption of blood may elevate the temperature one or two degrees, but after two or three days the temperature returns to the normal.

In cases of suppurative synovitis the general symptoms reflect the greater gravity of the local condition. With the systemic absorption of the products of inflammation the usual accompaniments of toxæmia, chills and continuous fever, coating of the tongue, and anorexia, are found.

The general symptoms of *acute suppurative arthritis* are proportionate to the severity of the local condition. Almost from the beginning the temperature rises from three to five degrees, and continues with morning remissions until vent is given to the inflammatory products or until death ensues from exhaustion. The fatality of this condition has already been referred to in the section on Penetrating Wounds of the Joints.

In the *dry form of synovitis* many of the local symptoms of the serous and purulent variety are absent. Pain and tenderness are often very marked, and out of all proportion to the swelling, which, as a rule, is slight. In these cases the tendency to faulty position is very early developed. When efforts at motion are made crepitus is felt. Movements of the patella upon the front of the femoral condyles may likewise elicit such joint crepitus. When the latter is insufficient to be felt it is distinctly audible when the ear is placed over the joint and the articular surfaces are moved upon each other. Passive movements are more painful than in the synovitis with effusion, and the pain associated therewith increases with the tendency to the formation of *adhesions.* The latter may form as early as the first week, and be firm enough to demand the anæsthetizing of the patient for their severance and the correction of the concomitant deformity. The general symptoms in cases of acute dry synovitis are often out of proportion to the severity of the local condition.

ETIOLOGY.—The etiological factors of acute diseases of the joints may be divided into the *traumatic* and the *non-traumatic.* The former have been sufficiently considered under the head of Joint Injuries. Without the history of a trauma, acute inflammation occasionally develops without any recognizable cause. *Non-traumatic joint inflammations* are often *secondary* to lesions in the vicinity of the joint. Acute inflammations of the joint-structures also often develop by extension from disease in the vicinity.

Chronic osteitis, periarticular abscesses, epiphyseal osteomyelitis, or erysipelas of an extremity may by extension of the process involve a joint in the vicinity. Suppurative disease in the *tendon-sheaths* of the hand and foot are not infrequently the cause of acute destructive inflammation of joints. Direct perforation of the joint-capsule from the outside does not ordinarily take place in this process, but it is through the slow invasion of the capsule by the pus-formers from without that the disease is grafted on the joint interior.

A *tubercular nodule in the epiphyses* by breaking into the joint will speedily set up a synovitis which at first is serous. Many of the non-traumatic inflammations of joints are but the manifestations of systemic involvement, and may therefore be called infective. *Pyæmia, puerperal fever, gonorrhœa, the acute exanthemata, rheumatism,* and *gout,* all have, as frequent complications, one or other form of acute joint disease, limited according to the severity of the local infection either to the synovial membrane or deeply involving the structures entering into the joint formation.

The synovitis of *pyæmia* and *puerperal* fever is ordinarily characterized by the involvement of more than one joint, either simultaneously or in succession. The

joints affected are usually the larger ones, like the knee and shoulder. Generally the joint effusion is purulent from its inception. The pus when evacuated is usually thin and flaky, but often is very foul. *The acute exanthemata*—with which for present purposes might be classed *typhoid fever*—which most frequently are followed by synovitis in their relative order are variola, scarlet fever, measles, and typhoid fever. As a rule, the joint complication develops during the period of convalescence, and, except in the case of variola, is ordinarily serous in its character. In variola, however, suppuration of the joint is not at all uncommon. In the suppurative processes of joints which occasionally accompany the acute infectious diseases the specific microbe of the individual disease has not been found in the joint effusion. The staphylococcus aureus has been most frequently observed, and in graver infections the streptococcus. In the arthritis following typhoid fever, the hip is more frequently affected than any other joint. Occasionally suppuration does not take place and complete recovery may ensue. More frequently, however, the joint lesions leave in their wake *ankylosis* or *spontaneous dislocation*. In 43 cases of joint disease from typhoid fever collected by Keen, 30 were subjects of spontaneous luxation, of which 27 were of the hip, 2 of the shoulder, and 1 of the knee. The synovitis which is the chief symptom of rheumatism is sufficiently characterized by the rapidity of the joint effusion, its serous character, and, above all, by the periarticular swelling and redness and the number of joints that are simultaneously or successively involved.

Gouty synovitis is but a manifestation of the general condition. It is serous, limited, usually to the metatarso-phalangeal joint of the left foot, associated with extensive periarticular swelling and redness. Through the soft parts, after the subsidence of the acute disease, nodules of calcareous deposit can often be felt within and about the joint structures, more or less defacing the joint outline and limiting motion to a varying degree. The subjective symptoms of pain and of tenderness are far in excess of the local underlying conditions. Both rheumatic and gouty synovitis are further characterized by their tendency to become subacute and even chronic. The structural changes involve the cartilage, ligaments, and periarticular structures. Both of these forms of synovitis, but particularly the gouty, are characterized further by their tendency to recur.

Post-gonorrhœal synovitis, when it develops, usually appears during the period of greatest activity of the primary urethral disease. In the great majority of cases, therefore, it will be found before the end of the third week. Immunity from a synovitis, however, does not exist until the complete cessation of the discharge.

While it is uncommon, gonorrhœal synovitis occasionally develops as a complication of what appears to be an insignificant gleety discharge. (See Chapter XI.) Special predilection is shown for the knee. Of 209 cases tabulated by Lagrange, the knee was affected in 83, the ankle-joint in 32, fingers and toes in 23, the hip in 16, the wrist in 14, the shoulder in 12, and the elbow in 11. That all joints may become involved is shown by this tabulation, to which the temporo-maxillary, the sacro-iliac, and the sterno-clavicular joints afford a contingent. As a rule, gonorrhœal synovitis affects one joint at a time, but it may be polyarticular. It appears more frequently in men, but does not altogether spare women.

Closely allied etiologically to gonorrhœal synovitis is what might be termed *urethral synovitis*. Occasionally the passage of a sound or a catheter in a urethra apparently normal is followed by a joint affection indistinguishable from that under consideration.

The relation of gonorrhœal synovitis to the primary disease is not clearly understood. Most careful observers like Kammerer, Petrone, and Bousquet have found the pathogenic diplococcus of Neisser in the exudate removed from a gonorrhœal synovitis. *Per contra*, in the hands of many observers the search

has been negative. The discrepancy may be due to the fact, as Kammerer has pointed out, that it is only during the height of the disease that the specific germ of Neisser can be found. In a very recent case of gonorrhœal synovitis he discovered the diplococcus; on making an arthrotomy on the same case eighteen days later the search proved negative. Usually gonorrhœal synovitis is serous in its character; very rarely it becomes suppurative. In the latter cases ordinary pus-formers have been found more frequently by all investigators than the specific gonococcus.

The DIAGNOSIS OF GONORRHŒAL SYNOVITIS is not difficult when the presence of the primary disease is known. From ordinary rheumatism it may be recognized by its being mono-articular, by the low range of temperature, the absence of the profuse sweating and heavily-loaded urine characteristic of rheumatic disease. Gonorrhœal rheumatism (as it is too often misnamed), as a rule, retrogrades slowly toward recovery. Often, however, the effusion becomes permanent. In other cases the plastic material thrown out tends toward the formation of fibrous ankylosis. Most ankyloses of the knee that are not the result of tuberculosis or trauma in young male subjects owe their origin to gonorrhœal infection. *Syphilis* very rarely produces primary acute articular disease. Occasionally during the eruptive stage joint pains are complained of. Serous effusions do not occur frequently, and are almost altogether limited to the knee. Ordinarily, the joint complications of syphilis are secondary to gummatous deposits in the epiphyses. In the hereditary syphilis of early life multiple joint lesions of this nature are often seen.

TREATMENT.—The treatment of acute inflammation of joints has a fourfold object: First, the *limitation of the inflammatory process;* second, the *removal of the products of inflammation;* third, the *prevention of deformity;* and fourth, the *restoration of full physiological function.*

(1) Among the *methods of curtailing inflammation* may be mentioned, in the first place, *position* and *rest.* In inflammation of the larger joints of the upper, and of necessity of the lower extremities, the patient must be put to bed. In diseases of the knee, the ankle, the elbow, and the wrist the limb should be *suspended at nearly a right angle.* The disadvantage given by position to the arterial circulation is often of itself sufficient to cut short an attack of synovitis. Unfortunately, in inflammatory conditions of the hip and of the shoulder these advantages cannot be obtained. Rest should further be secured by placing the part upon a proper splint, and the circulation should be as far as possible controlled by the application of an elastic bandage. As elsewhere, this should not be directly applied to the skin, which would speedily macerate, but over one or two thicknesses of gauze. When the tenderness and pain will not admit of such pressure the application of an *ice-bag* or *astringent lotions,* sugar of lead and tincture of opium or the chloride of ammonium, will be of service. The general condition of the patient in the simple form of synovitis rarely requires any special attention.

(2) For the *removal of the products of inflammation* the preparations of iodine, of mercury, and of lead have been used from time immemorial, but with rather doubtful results. The repeated use of *blisters* and of the *hot iron* will not infrequently, in cases that have passed through the acute stage, cause a speedy and permanent reduction of the joint swelling. To further facilitate the removal, and at the same time ensure joint fixation, fixed dressings, like the plaster-of-Paris, the starch, and

the silicate-of-soda bandage, have been highly recommended. Their use, however, should be limited to ten days or two weeks at a time, after which an inspection of the joint is necessary to forestall the development of ankylosis. Very effective in hastening absorption of serous products of inflammation is *massage*. When methodically applied once or twice daily, and followed by the use of elastic compression, it will remove the great majority of synovial effusions. As auxiliary to the local treatment very great faith may be placed in the internal administration of the iodide of potassium. When, notwithstanding the procedures here described, the effusion continues, recourse should be had to *aspiration of the joint*. This should not be delayed more than two or three weeks, lest the relaxation of the periarticular structures leaves the joint in a permanently weakened condition. The aspiration should always be done with the strictest aseptic precautions, a large needle being used and an oblique puncture being made through the overlying soft parts. All of the fluid of course cannot be removed by aspiration. The removal of only a part, however, will relieve the intra-articular tension to a degree compatible with the function of absorption by the synovial membranes. In not a few cases, particularly of the subacute variety, the tendency to the reaccumulation of fluid is great. When one or two aspirations have failed, a permanent cure can ordinarily be secured by the *injection* into the joint-cavity of two or three drachms of a 5 per cent. solution of carbolic acid. This injection should preferably be made through a large trocar, the joint being distended with as much of the solution as it will hold, when all but two or three drachms are allowed to come away through the cannula. In cases of pyoid effusions relief will not ordinarily be obtained without this treatment.

In cases of suppurative arthritis efficient drainage must be secured at the earliest possible moment. It is only by early and efficient drainage that the joint function can in a measure be saved.

In very many instances the removal of the entire synovial membrane and as much of the articular ends of the bones as may be diseased (*arthrotomy*) would prove the best conservatism practicable. It is only in the exceptional cases of acute articular suppuration that recourse must be had to amputation.

(3) *Deformity is to be prevented* by giving the limb a proper position from the very beginning, and one which, in the event of ankylosis, would leave it most useful. The knee should therefore always be kept extended, the elbow at nearly a right angle, and the wrist midway between pronation and supination. In diseases of the hip the leg is to be extended. As the tendency to deformity often manifests itself early, it may be already present when the case first comes under observation. At any cost this should be corrected as soon possible, either by gradual extension or, if need be, forcibly under general anæsthesia. By the use of proper support the recurrence of the deformity can ordinarily be obviated.

(4) *Restoration of function* is the most difficult achievement in the treatment of acute joint diseases. It can be met only by properly conducted passive movements, instituted as soon as the height of the inflammatory action has been thoroughly passed. The restoration of joint function must be particularly cared for in cases of synovitis which early

manifest a tendency toward joint fixation. Such are the dry synovitides and those which complicate gonorrhœa and the acute exanthemata. In these cases the use of an immobile dressing for two or three weeks will often permanently impair joint movement. Where it is already impaired passive movements and massage are most serviceable in restoring joint function.

Chronic Diseases.

Hydrarthrosis.—This term is used to designate a *serous effusion into a joint with a tendency to chronicity.* Strictly speaking, it is not a disease, but a result common to many conditions in and about the joints. Often in its inception it is the result of an irritation or an inflammation, the acute synovitis having become chronic. On the other hand, the effusion is often the result of changes in the vicinity of joints.

A *tubercular* or *gummatous nodule* in an epiphysis or a sarcoma of the epiphyseal end of the bone will occasionally be associated with a serous effusion into the adjoining joint-cavity. *Chronic articular rheumatism* and *osteoarthritis* are also at times associated with joint effusion, although, as a rule, in these cases the hydrarthrosis is limited in extent. Retarded circulation that in other parts produces an œdema will at times be followed by hydropic effusion into the joints. The local retardation of circulation, such as occurs in *phlegmasia alba dolens*, is not infrequently followed by an effusion into the knee which may continue long after the subsidence of the primary lesion. There are other cases, however, in which, without any of the causes named, hydrarthrosis develops, and in which the etiology is altogether unknown. An interesting class of cases was described as *hydrarthrosis intermittens* by Seeligmüller in 1880. In this form of disease the effusion recurs at fixed intervals, usually in both knees. It reaches its height often in a few hours, continues unchanged for from forty-eight to seventy-two hours, and then disappears. In a case seen by the writer this condition continued during three years without leaving the joint permanently damaged or seriously interfering with locomotion, even during the height of the effusion. In only two of the recorded cases was there a previous history of malaria.

Larger joints, like the knee, the elbow, the shoulder, and the hip, are often the seat of hydrarthrosis, although the knee is affected more frequently than all of the rest of the joints together. The character of the effusion is ordinarily *serous;* occasionally it is tinged with *blood*, and contains at times shreds of fibrin, free globules of *oil*, and, in old-standing cases, *fat-crystals.* In its amount it varies materially. In the knee there may be just enough of an effusion to efface the patellar grooves, or, in old-standing cases, as much as a pint. With the long continuance of hydrarthrosis, irrespective of its cause, certain structural changes result. The synovial membrane in its deeper layers becomes very considerably thickened; the folds or reflections show marked induration, and can often be felt in distinct ridges. The synovial fringes become enlarged, œdematous, and by proliferation far more numerous than in the normal condition. The articular surfaces of the bones are ordinarily unchanged. The important ligaments do not usually become relaxed, so that pathological displacements are never seen.

Although in long-standing cases of hydrarthrosis appreciable muscular atrophy ensues, *contractures* are very uncommon. Only so far as the presence of the fluid acts mechanically is the joint function restricted. When the accumulation is large, the bursæ with which the joint is in communication ordinarily participate in the effusion, thereby giving to the joint surface an uneven, at times lobulated,

appearance. When, as at times occurs, the hydrarthrosis disappears spontaneously the bursal effusion may remain unchanged.

The DIAGNOSIS OF HYDRARTHROSIS of the knee, the elbow, the wrist, or the ankle is easily made. Effusions into the shoulder and hip can only be recognized directly when they are quite large. The wave of fluctuation in extensive effusion is distinct. The articular outlines are effaced, and in the knee the ballottement of the patella can be easily demonstrated. The chronicity of the condition, its slow development, the absence of rise of temperature and of pain, confirm the diagnosis.

The PROGNOSIS OF HYDRARTHROSIS is largely that of the underlying condition. In the simpler forms spontaneous cures occasionally result. As a rule, considerable fluctuation in the quantity of the effusion is manifested. A partial or total absorption will often be followed by an increase and reaccumulation of the fluid.

TREATMENT. — In comparatively recent cases of hydrarthrosis absorption may often be secured by the treatment advocated for acute synovitis with serous effusion. *Friction*, methodical *massage*, repeated *blisters*, and the continuous application of an *elastic bandage* will often effect a permanent cure. In the failure of these measures recourse may be had to immobilization, from which the danger of ankylosis is not so great as in the cases of acute disease. In the majority of old-standing cases, however, recourse must be had to aspiration of the joint, to be followed by irrigation with a 5 per cent. solution of carbolic acid, of which from five to ten cubic centimetres may be allowed to remain within the joint. To make the injections painless, a $\frac{1}{2}$ per cent. solution of cocaine may be injected before introducing the carbolized water. In cases where even this has failed the draining of the joint may be resorted to.

A few cases have recently been recorded in which *free incision* of the joint has been made, the synovial surfaces thoroughly rubbed with pledgets of gauze, proliferated and hypertrophied synovial fringes removed, and the joint closed. A simpler method is what the writer would call that by *subcutaneous drainage.* A strand of silkworm gut is passed by means of a trocar through the affected joint: the ends of the strand are then carried subcutaneously through the periarticular tissues to a small incision made midway between the points of entrance and exit. After being tied the knot is buried and the wound of incision and, if need be, the punctures, are closed by sutures. The drainage is thus carried into the periarticular subcutaneous tissue, which does the absorbing, and through which and through the joint there passes a strand of silkworm gut. After a cure has been effected the silkworm gut, if need be, can be readily removed.

Chronic Articular Rheumatism.—This is a condition of advanced life and often found in the lower social strata. Individuals who have always been well nourished are not often subject to this disease. It occurs oftener in men who have led exposed lives: the earlier decades of life are, as a rule, exempt. The disease may follow in the wake of an acute rheumatic attack; generally it is subacute or chronic from its inception. Like its acute prototype, it is *polyarticular*. The pathological changes of chronic articular rheumatism vary with its severity and duration. Joint effusions are ordinarily limited in amount, if at all present. Primarily, the synovial membrane, the capsule, and the periarticular structures are involved. The synovial membrane becomes thickened, the ligaments indurated, and periarticular fasciæ show a tendency to become fixed.

Consequent upon this irritative hyperplasia, the joints often become fixed and a fibrous ankylosis results. The cartilages and the articular ends of the bones remain unchanged for a long time. It is only after prolonged fixation that cell-proliferation in the cartilaginous covering takes place, followed by abnormal bone-formation. This metamorphosis of bone occurs relatively often in the small joints, particularly in women over thirty.

The SYMPTOMS AND COURSE OF CHRONIC ARTICULAR RHEUMATISM correspond to the morbid conditions described. Mild or severe pain in one or more joints will be complained of. This is associated with restricted movement in the respective joints. There is usually an absence of redness over and about the joint, and tenderness is never excessive.

Joint motion is very often associated with a distinct crepitus. With the continuance of the process restriction of motion and faulty position will often eventuate in the disability of an entire limb. It is in this way that, by the multiplicity of joints involved, the subject of chronic articular rheumatism is often permanently invalided. Acute exacerbations of the chronic disease are of frequent occurrence.

The DIAGNOSIS is ordinarily easily made. The conditions with which it may be confounded are arthritis deformans and the articular affections consequent on diseases of the spinal cord.

The TREATMENT of this condition is chiefly general. During the acute exacerbation sodium salicylate is as serviceable as in the typical acute articular disease. During the intervals alkaline waters, particularly those containing lithia, have been found efficient. Sulphur and mud baths, when long continued, seem also to have proven serviceable. Methodical massage may accomplish much in overcoming joint fixation, hastening the absorption of effused fluids and reducing the thickened capsule and periarticular structures.

Osteo-arthritis.—This is a condition of degeneration and proliferation of the structures entering into a joint, the morbid anatomy of which forms a distinct entity. The causes which bring about the changes are far from being clearly apprehended. It is for this reason the disease has been variously named *rheumatoid arthritis*, *arthritis deformans*, *dry arthritis*, *trophic arthritis*, according to the views entertained concerning its nature. For the most part it develops by predilection in individuals past middle life, many of whom present evidences of arterio-sclerosis. Occasionally it develops in young subjects, preferably in girls after the appearance of menstruation.

As the immediate CAUSE of osteo-arthritis *trauma* plays a most important rôle, particularly about the hip, rapid changes of an osteo-arthritic nature following contusions of and about the trochanter. Within three or four weeks most extensive changes may occur *which simulate the conditions following a fracture*. Medico-legally, the knowledge of a trauma as the exciting cause of an osteo-arthritis is of signal importance.

In the selection of the joints affected the small joints of the hand and of the foot often show the process first. Among the larger joints, the hip, the knee, and the shoulder are most frequently involved. As a rule, this disease is *monoarticular*, although in individual instances two, three, or even more joints are involved. In very exceptional cases the number is very large (Fig. 237). Particularly does this apply to the joints of the spine, which by osteophytic growth may practically be rendered a solid column.

In its clinical manifestations osteo-arthritis, except in the rarest cases, is characterized by its chronicity and the tendency to joint fixation, not by obliteration of the joint-cavity, but by the development of *osteophytic processes* which mechanically impede motion. Pain is one of the chief symptoms of this disease. The joint, as a rule, shows early the deformation of its contour. The ligaments are thickened, prominent, and indurated; often bony deposits can be felt within them and continued into the periarticular fasciæ and tendons. In the early stages joint distention by fluid can occasionally be made out, although, as a rule, the process is one in which synovial fluid is rather reduced than increased in quantity. In accordance with this, the patient often experiences a distinct creaking or grating when he makes an attempt at motion, and therefore stiffness and pain in the part will be complained of in the morning until the joint has been considerably used after a night's rest. Acute exacerbations following a trauma, for example, or a breaking off of one of the osteophytic growths, may be followed by hemorrhage or serous effusion into the joint. This condition usually subsides more readily in cases of this character than in joints that are otherwise normal.

FIG. 237.

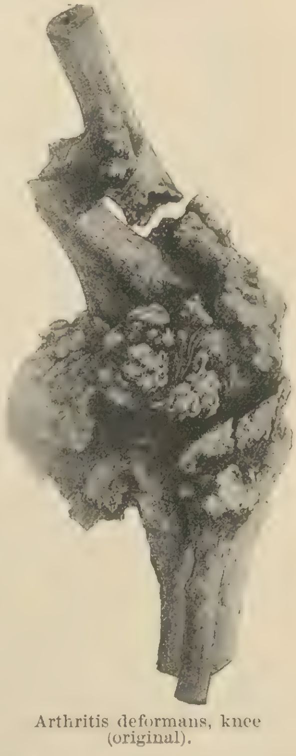
General osteo-arthritis, with multiple synostoses ("ossified man") (Park).

MORBID ANATOMY. — Although all the structures entering into the joint are ultimately involved, the first changes are observed in the articular cartilages. The disease begins usually with a proliferation of the deep layers and a rapid multiplication of the cells within the capsules. Where the joint surfaces must press upon each other the matrix of the cartilage becomes fibrillated, almost velvety. Where there is less pressure on the joint surfaces the proliferation of the cartilage-cells proceeds, while the matrix remains intact. In the *periphery*, therefore,

the process is *formative.* Thus there are formed *ecchondroses,* which are most marked along the borders of the joint surfaces, with a distinct tendency to outgrowths into the synovial membrane and the capsule where it joins the epiphyseal margin. The process of destruction proceeds in the central portions of the joint, where, by attrition, the fibrillated portions of the cartilages are removed and the underlying bone-tissue becomes exposed. The changes in the latter tend toward a complete obliteration of the meshes of the uppermost lamellæ, a compact layer of unusual hardness taking the place of the normal cancellous bone; thus the eburnated surface of one bone grates against its fellow. Any unevennesses which may have been present soon cut furrows into the yielding surface opposed to them; therefore in many cases osteoarthritis is characterized by grooves and ridges alternating with each other on the surface of a bone involved in the disease. Their presence explains why in joints so deformed motion is often limited to a single plane.

The proliferation of the cartilage along the periphery of the articular surfaces and into the margins of the joint-capsule presents marked tendency toward ossification. Osteophytic growths develop along the margins of the articular surface, thereby producing a distinctly *lipped* appearance. Often the entire circumference of a joint will thus be ensheathed by new bone-formation. Frequently these processes entirely change the outline of the joints, as will be seen by reference to illustrations, wherefore the name of *arthritis deformans* happily designates the morbid condition, as seen in advanced cases (Fig. 238). The capsule and ligaments often present osseous plates within them, the joint-fringes are early enlarged, often presenting infiltrations with various forms of connective tissue, fat, cartilage, or bone. The eating away of one or more of these processes is a fruitful source of the development of foreign bodies within the joint. The synovial membrane never becomes entirely obliterated, wherefore ankylosis does not occur in this disease. A vestige of the joint-cavity is always present. The joint becomes locked by proliferation of bone about it; a true ankylosis, however, rarely, if ever, takes place. By attrition, absorption of existing and deposition of new layers of bone go on synchronously. It is in this manner that, as the head of the femur, for example, in *morbus coxæ senilis* (which is arthritis deformans of the hip) becomes absorbed, the acetabular rim is widened and made shallower by deposition of new layers of bone. In this process of absorption the head of the femur may almost disappear, the neck be reduced to a right angle or less, and the entire length of the femur shortened by from three to four inches.

Fig. 238.



Arthritis deformans, knee (original).

SYMPTOMS.—The beginning of arthritis deformans, except when it follows a trauma, is ordinarily insidious. *Pains* varying in their intensity, but often severe and associated with creaking of the joints and moderate joint effusion, are among the earliest clinical manifestations. Very frequently the pains are of a neuralgic character. In the hip, for example, they are referred to the sciatic nerve. The *joint deformity*, however, usually manifests itself early. Irregular nodules appear, grow slowly, and show no tendency toward absorption. With the temporary *joint effusion* and the pain, muscular contraction often manifests itself early, fixing the joint in an abnormal position.

The COURSE of the disease is ordinarily chronic, continuing at times for from three to ten years or more. Exacerbations consequent on trauma are frequently shown; severer injuries may produce fracture or dislocation.

TREATMENT.—The treatment of osteo-arthritis is extremely unsatisfactory. In every feasible way joint movement should be maintained by active and passive movements. Massage may also be advantageous. Fixation by immobilizing dressings is to be strenuously avoided.

Operative treatment is not often called for, although in younger individuals, and particularly when the disease affects only one joint, excision may be resorted to in cases where the pain is very severe or the limb rendered useless. In a number of cases in which König made excision recurrence of the disease did not ensue during six years after the operation. A resected elbow-joint performed its function well, although the arm was weak. A knee united firmly, although the patient was over sixty years of age. In two excisions of the hip of patients, aged respectively seventeen and twenty-eight years, the result was very satisfactory.

NEUROPATHIC DISEASES OF JOINTS.

Although M. T. R. Mitchell called attention to the joint complications of nervous diseases in 1831, it was not until their classical description by Charcot in 1868 that they were given a fixed position in articular pathology. Whereas joint complications may follow injuries of the peripheral nerves or of the spinal cord, they are for the most part associated with the chronic diseases known as *locomotor ataxia* and *syringomyelia.* Notwithstanding great variations in the mode of development and the rapidity of their course, neuropathic arthritis appears under two forms clinically, the *benign* and the *malignant.* The former begins as an acute or subacute swelling of the joint and the periarticular joint structures. There is a serous effusion into the joint, which may after a short time be absorbed, the disease being unmarked by either fever, pain, or redness. The *malignant* type, according to Charcot, is found exclusively in tabetic subjects. With or without absorption of the serous effusion the joint-capsule remains relaxed and weakened, the ligaments show a tendency to undergo softening, and the articular ends of the bones are rapidly destroyed.

The MORBID ANATOMY would permit the logical division of neurogenous arthropathies into the *atrophic* and the *hypertrophic.* In the latter, proliferative processes in the cartilages, the capsule, and the periarticular structures predominate, since, as in cases of arthritis deformans, extracapsular stalactitic growths and exostoses are of common occurrence. Atypical bone-formation is also found in the contiguous tendons and fascia. In the atrophic arthropathies, on the other hand, the degenera-

tive process predominates and leads to the destruction of the bony components of the joint. Often the entire epiphysis is changed in its conformation. Where, after destruction of the cartilaginous covering, attrition takes place, absorption follows, the process being one of rarefying osteitis.

The head of the femur may be absorbed without leaving scarcely a trace (Fig. 239). In the knee absorption causes the disappearance of the condyles and of the head of the tibia. Thus a disproportion is established between the area of the joint surface as a whole and that of its component bony parts; thereby is produced a flail joint, and as characteristic of this condition the tendency to luxations and subluxations. The arthropathies of nervous origin affect chiefly the knee. In 56 observations by Barry the knee was affected in 33, the hip in 15, the shoulder in 10, the joints of the foot in 11, the elbow in 8, and the joints of the hand in 1. In 66 cases the arthropathy was mono-articular; in 25 more than one joint was affected. As a rule, joint complications do not supervene in tabes until the latter is well marked and has existed for from three to five years. It may develop before the tendon reflexes are lost, and occasionally it appears as the initial symptom.

FIG. 239.

Disappearance of joint end of femur in neuropathic atrophy (original).

SYMPTOMS.—The onset of the disease is ordinarily sudden. Without apparent exciting cause the joint and periarticular structures are swollen, and œdema may involve the entire extremity. The latter usually disappears rapidly, leaving the hydrarthrosis (Figs. 240 and 241). In a number of cases the joint effusion is preceded for a number of days by a grating sensation. The periarticular œdema has been ascribed by DeBove to a detachment of the joint-capsule from the bone, and the consequent effusion of the synovia into the periarticular tissues. In 23 out of 56 cases the onset was gradual. Most of the cases are marked from beginning to end by complete absence of pain and of local and general manifestations of inflammation. Except for the abnormal mobility of the joint and the consequent tendency to faulty position, the patient need not be embarrassed by the presence of the arthropathy. In a few cases, spontaneously or through trauma, the *joint has been opened.* The joint perforation in these cases has not been followed by the disastrous consequences of like lesions in normal joints. Preternatural mobility is characteristic of this condition. The knee, when the patient is erect, is thrown backward, with the receding angle in front; in the hip external rotation can be carried to the point of bringing the heel forward. Except for the often enormous joint distention in tabetic disease of the shoulder, the upper extremity assumes the position of one in which excision of the shoulder-joint had already been made.

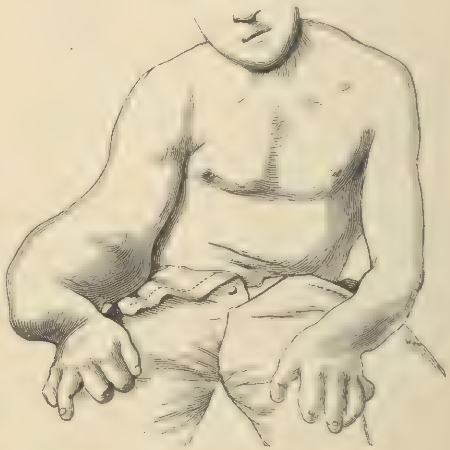
The DIAGNOSIS of neuropathic arthritis is ordinarily easily made. Aside from the symptoms of the parent affection, the rapid course of

the disease, the relative freedom from pain, the large joint effusions, the local anæsthesia, the muscular atrophy, the relaxation of the ligaments, and particularly the age of the patient, are sufficiently diagnostic. The condition with which it may most readily be confounded, *osteo-arthritis*, afflicts for the most part older individuals, is associated with severe pain and joint fixation, and is essentially slow in its development. It is only in the hypertrophic form of neurogenous joint disease that the diagnosis can become difficult.

FIG. 240.

Charcot's disease.

FIG. 241.



Charcot's disease of elbow.

TREATMENT is palliative. When the effusion is extreme temporary benefit may be obtained, as in a case recently operated on by the writer, by tapping and injection of carbolic acid, as in the treatment advocated for hydrarthrosis. Joint fixation by proper appliances or retentive dressings may be of avail in locomotion. When the disease is limited to the knee, recourse may be had to excision with a hope of securing a firm limb. Rotter has thus excised the knee in 4 cases, with fair results in 2.

Hysterical Joints.—As a result of slight trauma or over-exertion—as, for example, in dancing—and very frequently without any exciting cause, there develops in hysterical subjects a train of symptoms which, to casual observation, may closely simulate organic joint disease. From the time of Brodie the joints thus apparently affected have been designated as *hysterical joints*. The individuals usually afflicted are girls and young women, sometimes pregnant, otherwise well nourished, and generally in the higher walks of life. They may or may not display other phenomena of hysteria or allied neuroses. The joints most frequently involved are the hip, the knee, and the ankle. Clinically characteristic of an hysterical joint is the disparity between the intensity of pain complained of and the local manifestations.

Although, from hysterical paresis or voluntary muscular contractions, the limb may assume an abnormal position, the *joint contour is never interfered with.* From sluggishness of the circulation the part may present a subnormal temperature, be given to profuse perspiration, and from disuse present slight muscular atrophy. Fixation of the joint, such as occurs in organic disease, is never present except during the waking hours. During sleep, particularly that induced by anæsthesia, absolute relaxation is obtained and joint movement to a normal degree readily elicited.

Another clinical characteristic of the condition is the *variability of the position* assumed by the limb. The variations often follow each other at short intervals. A sign to which Brodie called particular attention is the *intense hyperæsthesia* of the joint and of the overlying integument. This is more marked even than the tenderness of the joint in organic disease, in acute articular rheumatism, or in an acute periarticular abscess about to rupture. The pain of hysterical joints manifests itself only during the *waking* hours. The starting-pains complained of at night, so characteristic of some forms of organic disease, are seldom seen in hysterical joints. In very rare instances organic diseases have been complicated by the exaggerated suffering of hysteria, but here the permanency of muscular contractures, joint fixation in one position, and the test by anæsthesia will make the diagnosis clear.

The PROGRESS of an hysterical joint keeps pace with that of other manifestations of hysteria. As a rule, under proper treatment it disappears rapidly, although in exceptional instances it continues for months and even years. An hysterical hip known to the writer withstood all forms of treatment during four years, to become finally dissipated in a single night through the agency of the faith cure.

The TREATMENT of an hysterical joint should be directed toward the psychical condition of the patient. When once thoroughly assured that that there is no serious disease present, applications of electricity and massage will ordinarily speedily cause the symptoms to disappear. Too much attention should not, however, be given to local treatment, and retentive appliances and dressings should be strenuously avoided.

Loose Bodies.

In previously healthy joints or joints that have been diseased there are not infrequently found bodies varying in size, number, and histological construction, either *loose* and contained within the joint-cavity or *adherent* at some point by a pedicle of varying length and thickness. The joints oftenest the site of loose bodies are the knee and elbow. The former is involved in nearly 86 per cent. of all cases. In the remaining joints foreign bodies are only exceptionally found. In joints that have been free of disease these loose bodies—or floating cartilages, as they are often termed—are invariably the result of a *trauma.*

Experimentally, it has rarely been found possible to tear away fragments of bone and of cartilage, although accidents doubtless occasionally produce results that cannot be wilfully duplicated in the cadaver. Paget, Teale, Fuerer, and others have reported cases in which portions of the external condyle with the overlying cartilages have either been loosened from their attachment by the trauma itself or soon thereafter by attrition.

Allied to this class of cases is that known as the **internal derangement of the knee**, where, in consequence of a violent wrench, one of

the *semilunar cartilages*, preferably the internal, has been loosened from its moorings to the tibia and the coronary ligament, and is deflected toward the joint interior. First described by Hey, the subject has been investigated particularly by Allingham and Bruno. Of 43 cases examined by operation or autopsy, the internal cartilage was luxated in 27; the external in 13; not stated, 3. Primary laceration of the *synovial fringe*, or its infiltration with blood and consequent exfoliation, may likewise be the source of a foreign body in a hitherto normal joint. According to Hunter, Shattuck, and Fisher, the organization of an *intra-articular clot* will sometimes give rise to a loose joint body. Finally, the penetration and encapsulation of a *foreign body*, like a needle, may, though rarely, be the nucleus of a loose body. In diseased joints foreign bodies may develop as a consequence of *fibrinous deposits* on the joint surfaces. By organization and long-continued attrition the deposits are broken up, as a rule, into large numbers of minute bodies varying in size from a grain of mustard to a bean. They compress each other into ovoid biconvex forms, and occasionally fill the joint-cavity. These **corpora oryzoidea**, or *rice-bodies*, have been so called from their **shape, size, and pearly appearance.**

The development of these rice-bodies is not always so simple. In many cases, besides presenting the striations of superimposed fibrinous layers, they show in the interior more or less distinct traces of organized tissue. Particularly in the hydrarthrosis which accompanies tubercular disease these rice-bodies have been often found. Their first development, then, is in connection with the synovial membrane, from the surface of which they sooner or later sever their attachment and become floating. The condition is analogous to that seen in tuberculosis of tendon-sheaths and of bursæ.

The *hyperplastic synovial fringes* observed in many of the diseases of the joints form another common source of these loose bodies, many of them floating freely within the joint, others fixed by more or less attenuated pedicles to the joint-wall. These synovial fringes may present all the histological variations of the connective-tissue types found in the make-up of the joint; therefore, these foreign bodies may be *cartilaginous*, contain *true bone*, consist of a mass of *fat*, present a *cyst* within their interior, and, in very rare cases, a mass of *mucoid connective tissue.*

In size these bodies vary very materially. The smaller ones, usually being etiologically of tubercular or inflammatory origin, are formed of the softer connective tissues, the larger bodies, as a rule, being made up of firm fibrous tissue containing cartilage and very often bone. The latter often measure two to three centimetres in length by one centimetre in width and thickness. When thus large the bodies commonly occur singly or in small numbers. In cases of *osteo-arthritis*, on the other hand, the entire joint interior may be filled with a large number of severed *osteophytic processes.* The condition of the joint itself shows the changes belonging to the disease of which the foreign body is but an incident. In the traumatic cases, besides the evidences of irritation produced by the foreign body, distinct defects have occasionally been seen on the articular surface which correspond in shape and size to the loose body, and evidently indicate a part from which the latter has been derived, either by the primary trauma or by the subsequent process of its severance therefrom. The foreign bodies not infrequently resemble small lipomata both in shape and structure. In joints that have previously been diseased they are due to the infiltration of the synovial fringe already alluded to. Of larger size, they can generally be referred to a trauma. They have only been found in the knee, where two subserous cushions of fat normally exist—the one underneath the patellar ligament; the other between the upper synovial pouch and the front of the femur. The rupture of the synovial membrane will

permit a hernial protrusion of a mass of fat into the joint, where, when connected with the parent mass by a pedicle, it may grow much as does an omental hernia within its sac.

As a result of long-continued irritation from a foreign body in the knee-joint of young subjects the femur has been found elongated one or two centimetres.

Symptoms.—The symptoms of loose bodies vary with their size, situation, mobility, and the conditions under which they were developed. When they are small and numerous, as in cases of *hydrarthrosis, tubercular disease*, and *arthritis deformans*, they produce few symptoms and rarely of themselves require attention. In the *larger bodies*—which, as we have seen, are directly or indirectly of traumatic origin—the symptoms are far more pronounced. Frequently their existence does not make itself manifest until the immediate results of the accident to the joint have largely disappeared. Thus, after a fall upon the knee, for example, a loose cartilage will occasionally be discovered a week or ten days after the injury and after a partial subsidence of the articular distention with serum and blood. In other cases months and years may pass after an accident before the loose body is discovered. In the largest number of cases the symptoms manifest themselves in consequence of the locking of the foreign body between the articular surfaces and the consequent violent stretching of the joint ligaments. An individual makes a misstep or an awkward movement, and suddenly feels an excruciating *pain* which compels him to stand where he is or possibly to sink to the ground. The limb itself usually remains *fixed* nearly in extension in the knee; in the elbow, at an angle of 130° or 140°. By a little manipulation the patient, or some one assisting him, brings the joint surfaces again into apposition, and except for some tenderness of the part and temporary effusion into the joint a return to an approximately normal condition follows. This incarceration of the foreign body occurs at intervals varying between a few weeks and as many years. Between the attacks the joint function, however, is rarely normal. Limitation of motion is very common. In the knee, the foreign body being usually in the anterior portion of the joint, or in the subquadricipital pouch, complete extension is not easily accomplished. In the elbow, the foreign body lodging more frequently in the anterior pouch, flexion to a right angle cannot be made. In cases of partial detachment of the semilunar body it can often be felt in its abnormal position and is but slightly movable.

A positive diagnosis of a loose body can only be made when it is *subject to palpation*. When felt it appears as a hard round body under the soft parts, usually over the interarticular line or in relation with the external condyle of the femur. Its position can ordinarily be shifted, and as a rule it disappears from observation, often for long periods. Through long experience the patient himself is often more successful than the surgeon in bringing it to the surface. As to the nature of the foreign body, pre-operative diagnosis cannot be made.

Treatment.—The multiple bodies which belong to the graver joint diseases, like tuberculosis and osteo-arthritis, very rarely require surgical intervention. In the larger bodies, which are the important factors in a diseased condition of the joint, the treatment is *palliative* or *radical*. The former consists in the wearing of an elastic bandage,

which will, in a measure, keep the foreign body from between the joint surfaces. The radical measure applicable to-day is *extirpation.* To transfix them by needles and bury them without the joint by subcutaneous measures must not be practised to-day. The excision, as a rule, should be made by an ample incision directly over the foreign body, which is held by an assistant, or, for the time being, transfixed by a needle. When, after the incision is made, the foreign body is not visible, manipulation of the joint surfaces will either bring it to the surface or expose it somewhere in the interior. In the latter event it can readily be drawn into the wound by means of forceps or blunt hook. If there be a pedicle, this should be cut off as close as possible, and preferably without previous ligation. It is always wise as far as possible to explore the interior of the joint for other foreign bodies, one of which might be readily overlooked in its more hidden recesses.

When the foreign bodies are small and numerous a very free incision must be made for their dislodgement, and only in these cases is lavage of the joint requisite. In the pedunculated growths from the synovial fringes many may unfortunately escape removal, and, growing, require subsequent operation. The operation itself must be done with the strictest precautions as to asepticism. The fatality of the operation in pre-antiseptic days was nearly 40 per cent. It has been reduced to almost nothing. With the removal of the foreign body the irritative changes produced by it rapidly subside, and joint function is almost completely restored. This applies particularly to the operative removal or fixation by suture of a ruptured or dislocated semilunar cartilage.

Tubercular Arthritis.

Through many centuries medical writers have described a disease of the joints marked by chronicity, swelling, and deformity, a tendency to the formation of abscesses, and the destruction of the joint. Among the many names which have been given to it may be cited : *tumor albus* or *white swelling*, *scrofulous* or *strumous disease*, *fungous disease* of the joint, *caries*, and *spina ventosa*. Since the important investigations of Friedländer and the discoveries by Koch of the causative relation of the specific bacillus to tuberculosis the term properly reserved for this destructive disease is *tubercular arthritis*.

Although tubercular arthritis may attack individuals at any period of life, it is most frequently developed before the period of puberty. While it is not common under one year, it sometimes develops in infants with remarkable rapidity.

Of 860 cases tabulated by Gibney, it developed in 84 per cent. in children under fourteen. In them the hip, the knee, and the ankle are the most frequently affected, in the order given. The shoulder and the wrist are not often the seat of the disease in children, whereas in adults they are relatively often involved. Particularly often is the shoulder the seat of tubercular disease in persons past the prime of life. In the majority of cases the disease is limited to one joint. In less than 5 per cent. of all cases it is polyarticular.

As in tuberculosis elsewhere, heredity appears to be a decided predisposing cause. Bollinger examined the antecedents of 250 cases of tubercular disease, and concluded therefrom that the disease occurred not so often in the children as in the *grandchildren* of phthisical subjects. In 401 cases of disease from the Alexandra Hospital reports, 24 per cent. presented a family history of phthisis ; 35 per cent. were ascribed to a

trauma. Over 90 per cent. of cases involve the joints of the lower extremity, which is subjected to traumata of slight degree infinitely more than the upper extremity. The relation between trauma and tubercular disease of the joint has been made plain since the classical experiments of Schüller, who demonstrated that animals which had been rendered tubercular by the inhalation of tubercular sputum developed typical local tuberculosis when the joint was subjected to injury of even moderate severity. This corresponds to the fact that severe injuries are rarely followed by tubercular disease, but that comparatively slight injuries to the epiphyseal ends of bone and to joints are often followed by local tubercular infection.

An *injury per se* produces tuberculosis only through the infection of a *blood-clot* or the formation of an *infective thrombus* in the epiphyseal end of bone. The source of the tuberculosis, particularly in children, is, as a rule, a *latent tuberculosis of the bronchial lymph-nodes.* Only in a small proportion of cases has the tuberculosis been found on autopsy in the bones alone.

König reported 66 autopsies of cases of tubercular arthritis in which only 13 failed to reveal latent tubercular foci. Landerer goes even farther in the statement that in 150 autopsies all save one or two presented disease of the lymph-nodes which evidently preceded the bone affection. Experimental research other than that of Schüller has shown the channel of infection. Injection into the joints of tubercular sputum or of true cultures, and into the nutrient vessels, have almost invariably been followed, in the hands of many experimenters, by the development of typical tuberculosis of the epiphysis, and secondarily of the joint. These experiments of Schüller, Watson-Cheyne, Müller, and Krause conclusively demonstrate the importance of trauma in the etiology of tubercular disease and the specific influence of the Koch bacillus.

Pathological Anatomy.—Tubercular arthritis in advanced cases includes in its destructive tendencies all of the joint structures. In its inception, however, it begins either in the epiphyseal ends of the bone, when it is called *osteopathic,* or in the synovial membrane, when it is known as *arthropathic.*

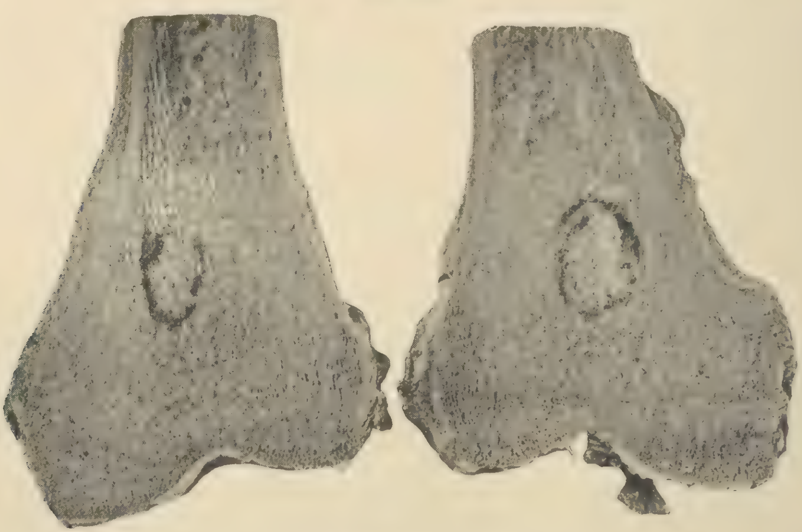
According to the investigations by Müller of specimens obtained in König's clinic, of 232 cases the primary seat of the disease was the bone in 158, the synovial membrane in 46, the origin was doubtful in 28. Of 61 cases involving the hip the disease was osteopathic in 47, arthropathic in 3, and doubtful in 11 cases. Of 118 cases of disease of the knee the bone was first involved in 69, the synovial membrane in 33, the origin of the disease unknown in 16. Of 53 cases of disease of the elbow the bone was first involved in 42, the synovial membrane in 10, doubtful 1.

Volkmann believed that in children the disease was almost invariably of osseous origin, whereas in adults the synovial type predominated. Nevertheless, according to the investigations of Müller, 76 per cent. of the cases occurring after the thirtieth year were probably developed in bone.

(*a*) **Osteopathic Arthritis.**—This begins, as a rule, as a well-outlined nodule of reddish-gray or yellowish color in the epiphysis. It may be situated near the epiphyseal cartilage or directly underneath the articular line. In very many instances it is first found near the periosteum or in proximity to the capsular attachment. Whereas, as a rule, it at first presents itself as a single nodule, there may be many. In the severest types of the disease the entire epiphysis is evenly occu-

pied by the infiltration. The bone about the nodule is distinctly hyperæmic, thereby accentuating the more subdued color of the tubercular nodule itself. In the hyperæmic area the bone trabeculæ are somewhat thickened, the cancellous spaces are devoid of fat-cells, and within them are often found miliary tubercles. These are often the means of the extension of the disease. As the central focus increases in its dimensions it becomes yellowish in spots from deficient nutrition and fat-necrosis. Thus there are found nodules varying in size from a pea to a nut, consisting of a soft cheesy material, early containing spiculæ of bone that have resisted absorption. Older nodules are made up altogether of this cheesy débris, and can readily be washed away or removed as an entity with the finger. This material has often been called tubercular pus, although it bears only a physical resemblance to the latter. At this early stage the nodule is contained within a cavity lined with granulation-tissue, thus constituting what is sometimes called the tubercular epiphyseal abscess. Very frequently the tubercular nodule, as has been shown by experiment, is of embolic origin. As in infarctions of the viscera, there then results infection of a wedge-shaped segment of the epiphysis, the base of the wedge being directly under the articular cartilage, the apex toward the epiphyseal line. The result

FIG. 242.



Central sequestrum (original).

of this is an epiphyseal necrosis, which, while it may be as small as a bean, may, on the other hand, be as large as the epiphysis itself. In very many cases such small epiphyseal sequestra may remain for years imbedded within the epiphysis, or, being absorbed by granulation processes, leave a cavity filled with serous exudation, or one that eventually closes by the formation of cicatricial tissue. So fortunate a termination, however, is the exception. As a rule, a tubercular nodule becomes surrounded by a layer of *granulation-tissue*, which in turn be-

comes invaded with *miliary tubercles*, and it is through the growth of this granulation-tissue that bone absorption takes place. (*Vide* Chapter IX.) Through the growth of the primary focus in the direction of the encrusting cartilage the joint itself, sooner or later, becomes involved. Even before a perforation of the encrusting cartilage has taken place there is a reactionary inflammation within the joint, as has been shown by Lannelongue, Volkmann, and many others who have operated early for tubercular disease (Fig. 243).

Before perforation ensues the synovial membrane becomes thickened, the cartilage over the tubercular epiphyseal focus shows signs of proliferation, and the vascular offshoot from the synovial membrane intervening between the articular surfaces in part causes adhesion between them with a tendency toward partial obliteration of the joint-cavity. This reaction may prevent joint infection or limit it to a part thereof. This is not infrequently seen in the knee. Generally, however, this takes place through direct communication of the epiphyseal tubercular focus with the joint interior. The granulations undermine the articular cartilage either in limited and numerous areas or as an entity. In the former the cartilage, having lost its pearly-white appearance, is cloudy, yellow, and presents numerous erosions, the floors of which are made up of fungus-like granulations. In other cases the entire encrusting cartilage, exfoliating as a mass, can be stripped from the underlying granulation-layer like the cuticle from a bleb (Fig. 243).

Fig. 243.

Tubercular panarthritis (original).

With the penetration of the tubercular focus into the joint a *panarthritis* is speedily developed. The capsule becomes thickened, the synovial membrane injected; it loses its smooth appearance and becomes covered with *fungous granulations*, within many of which will be found a miliary tubercle, as first described by Köster. With the thickening of the capsule there is infiltration of the periarticular structures, which in the more superficial joints may extend into the subcutaneous cellular tissue, binding down the skin, the fascia, muscles, and tendons to the joint-capsule. This infiltration is largely of a gelatinous nature, and but the result of the retarded circulation produced by the distended capsule. Within the joint there is, as a rule, found a little fluid, which is not pus in a strict sense, but is the product of the liquefaction of the cheesy substance in the dépôts and the cellular output of the fungous granulations (*pyoid* or *archepyon*).

At this time there is a manifest *enlargement of the joint*, which is emphasized usually by the wasting of the muscles above and below. Usually spindle-shaped, covered by an anæmic, often glistening, and

adherent skin, underneath which a few of the larger veins will be seen, the joint now presents the typical appearance of tumor albus, or *white swelling*, the *fungous* or *gelatinoid* joint disease (Fig. 244). In the majority of cases the capsule itself is softened at one or more places, whereby the granulation process becomes *extra-articular*. Sooner or later the skin

FIG. 244.

Tubercular panarthritis of elbow.

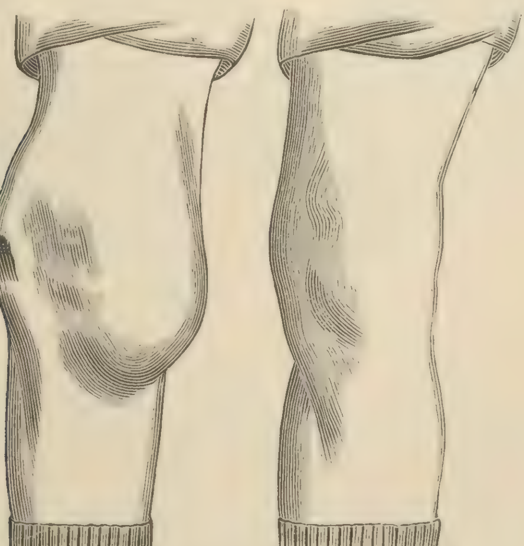
becomes involved from underneath, and the products of the tubercular disease escape through what is *incorrectly called a tubercular abscess*. From the absence of acute inflammatory signs such abscesses are sometimes designated *cold* abscesses. Such a periarticular abscess may develop without involvement of the joint. A subperiosteal nodule not infrequently makes its way to the surface, undergoes caseation, and remains extracapsular to the end.

As in other abscesses that have discharged, contraction usually takes place until a fistulous opening is left. The *sinus* leading to the tubercular focus is very often tortuous, and its cutaneous aperture far removed from the site of the disease. In long-standing cases of tubercular arthritis *many sinuses* are found, often undermining the periarticular tissue over large areas. With the formation of abscesses the process *ceases to be strictly tubercular*, for the infection with ordinary pus-formers, as a rule, takes place soon after the tubercular dépôt has been discharged through the skin. In the prognosis of tubercular arthritis this *secondary infection* is of the greatest moment, since it is more destructive to the joint, and even to life, than the primary disease.

(*b*) **Arthropathic Arthritis.**—When the *synovial membrane is primarily attacked* the tuberculosis may be diffusely disseminated over more or less of the entire area or be limited to one portion thereof, preferably one of its reflections or a synovial fringe. In the diffuse form there may be deposited a large number of miliary tubercles, without much change in the intervening tissue. The joint itself is not much altered. It is occasionally found in general miliary tuberculosis, of which it is only one of the many manifestations of infection. In other cases the *diffuse* tuberculosis of the synovial membrane is associated with increased

vascularity, as a product of which an extensive serous or sero-fibrinous exudation is found within the joint. This latter, which is known as *hydrops tuberculosis* (Fig. 245), must always be taken into consideration in the etiology of chronic articular effusions. The capsule itself is very often thickened by excessive vascularization, and as a product of this a more or less extensive deposit of fibrin will be found covering the synovial membrane and the articular cartilages. This may be extensive enough to completely cover the tubercular nodules. The partial organization of fibrinous deposit from proliferation of endothelial layers underneath will often give rise to the development of *rice-bodies* in large numbers, to which consideration has already been given. In the majority of cases the synovial membrane is very much thickened and softened, and within it there are disseminated tubercular dépôts of larger size, which also invade the subsynovial tissues. Commonly, there is only a slight increase of the synovial fluid, which soon becomes turbid and pyoid. As in the osteal form of tuberculosis, *granulation-tissue* develops from the surface of the synovial membrane and soon occupies the joint interior. From it are invaded the encrusting cartilages. Ordinarily these present a distinctly worm-eaten appearance, and it is from the periphery toward the centre that the process of invasion takes place (Fig. 243).

FIG. 245.



Tubercular hydrops of knee.

In the synovial form of tuberculosis the destruction of bone usually involves only the superficial laminæ, in marked contrast to that which is primarily of osseous origin. For the same reason, in the primarily synovial type of the disease there is a greater tendency to the involvement of *both bones* entering into the joint formation, whereas in the osseous form it is not rare to find the disease limited to a single epiphysis. The circumscribed type of synovial tuberculosis, as accurately described by König, is very rare. It presents itself in the form of a large *granuloma*, the tumor being as large as a nut or even as an egg. It is firm, grayish-red in color, and consists of embryonic connective tissue partly the seat of caseation

and often containing miliary nodules. (*Tyroma*, *vide* Chapter IX.) Occasionally it springs from the fibrous portion of the capsule; the synovial membrane may then long withstand infection. If left to itself, general infection of the joint takes place, from which result the conditions above described.

Repair in tubercular arthritis follows the paths by which recovery takes place in tuberculosis elsewhere. Its first evidences are found in the granulation-tissue, which loses its succulence from decreased vascularity and shows a tendency toward conversion into fibrous tissue. In this process small caseous dépôts are often left for years, and account for the tendency to recurrence of the disease. While it is certain that the bacilli do not live throughout such long periods, it is probable that their

Fig. 246.

Bony ankylosis of knee (original).

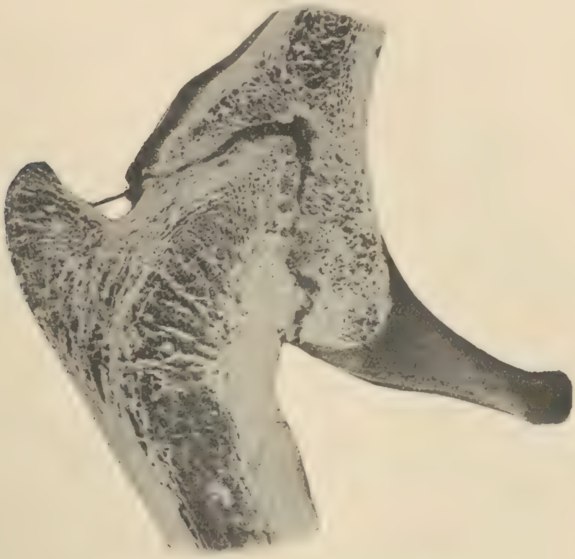
spores live and develop actively after a slight trauma sustained sometimes years after an apparent cure has been effected. (Although this explanation is hypothetical, it best accords with the clinical facts as often seen.)

In the process of cicatrization joint surfaces are often welded together by fibrous bands, thereby reducing the joint-cavity in size, and particularly obliterating the subtendinous joint-pouches. It is in this way that limitation of joint movement remains as a permanent result. When the disease has destroyed both encrusting cartilages, fibrous bands firmly unite the articular ends, constituting a common source of fibrous ankylosis. With long continuance of this condition the fibrous bands undergo ossification until, where the condition has lasted for many years, the cancellous systems of contiguous bones are merged into each other, often without more than a vestige of the pre-existing interarticular cleft, thus producing *bony ankylosis* (Figs. 246 and 247).

Symptoms.—The early stages of a tubercular arthritis are, as a rule, vaguely indicated by symptoms. *Occasional pains*, felt particularly

during sleep, and in the lower extremities a passing lameness, are the earliest indications of the disease. With its progress the symptoms become more pronounced. Those to which attention is earliest directed are *defective movement, swelling, deformity*, and *muscular wasting*. The first of these is among the most valuable aids in diagnosis. There is early seen a limitation of movement, which is most marked in the

FIG. 247.



Section of bony ankylosis of hip (original).

shoulder and in the hip, almost always present in the knee, and to a less extent in the wrist and ankle. *Tubercular hydrops*, which is oftenest found in the knee, may exist without limitation of joint movement. *Swelling and deformity* are early seen in all cases of tubercular arthritis except in the cases of the deep-seated hip and shoulder. The swelling depends on the pathological conditions above described. Though seemingly the deformity may be due to an enlargement of the bones, this in reality rarely takes place, and then only as an excessive repair. In very exceptional cases there is an *absolute elongation* of bone in consequence of tubercular arthritis. The deformity is very frequently enhanced by *partial* or *total luxation*. In the knee there is a tendency toward subluxation backward of the tibia on the femoral condyles, the latter becoming abnormally prominent. In the hip, what is left of the femoral head often leaves the deformed acetabulum, thereby producing great deformity with shortening. The deformity is almost always enhanced by vicious joint fixation.

Reflex contractures, invariably of the stronger flexor muscles, and *angular deformity* speedily ensue. The knee is flexed upon the thigh; the elbow becomes fixed at an angle of 120° to 130°; the wrist drops; the hip is flexed upon the abdomen; and the foot assumes the talipes-equinus position by the contracture of the stronger muscles which act upon the joints named respectively. The contracted muscles can

always be felt early as well-defined ridges in close proximity to the angle in which the limb is fixed. With the contracture there is often associated an *atrophy of the muscles* as an early evidence of the disease. Although the degree of atrophy may not at first be measurable, the flabby condition of the muscles is significant of its presence.

Pain varies materially at different periods of the disease and in the various types. It is most marked in the osteopathic form of the disease. In the synovial type, even when associated with large effusion, it may be slight or altogether absent. Whereas, as a rule, the pain is experienced in the joint involved, it may be *reflected*, as is the case notably in the hip, to parts far removed. Through fixation of the limb by muscular contracture motion does not necessarily increase pain. Children with advanced disease of the hip or of the knee often do not suffer at all, even from violent exercise. By substituting the functions of other joints for that of the one diseased motion in the latter is involuntarily reduced to a minimum.

The *constitutional complications* of tubercular arthritis are rarely marked in the early stages. Adults and children are seemingly in perfect health except for the local condition. In proportion as this extends the general condition suffers.

Careful observation will reveal an evening rise of temperature, although in the morning it returns to the normal. Particularly in the lower walks of life, where the disease is long neglected, the pain and the consequent loss of sleep will frequently give the children a haggard appearance, which, however, may be made to disappear with the institution of proper treatment. When the disease has produced extensive destruction of the joint and periarticular abscesses have developed, the temperature, as a rule, is continuously elevated, and the constitutional manifestations are not unlike those of visceral tuberculosis. If infection occurs with the ordinary pus-formers, the general health may be very rapidly undermined and death ensue from more or less acute suppurative toxæmia. Generally the suppuration is long continued, and if death from visceral changes occurs, it is only after many months or years of suffering. In the very great majority of cases proper treatment will localize the tubercular process. Nevertheless, cases are by no means rare in which a generalization of tubercular disease occurs, and particularly in disease of the hip. In children there is a marked tendency toward a tubercular meningitis. Improper treatment, and especially untimely and imperfect surgical interference, is often speedily followed by generalization.

The DIAGNOSIS OF TUBERCULAR DISEASE is, as a rule, easy. In fully 90 per cent. of the cases it is almost self-evident. Far more difficult is it to distinguish the individual types of the disease. The fungous variety of the superficial joints, like the knee, elbow, wrist, and ankle, is very easily recognized by the swelling, the deformity, and the sense of false fluctuation. More difficulty attaches to the recognition of a deep-seated tubercular nodule within the epiphysis. The condition with which this is most easily confounded is the epiphyseal gumma of late inherited *syphilis*. The presence of corroborating evidences of syphilis, rapidity of development, and, above all, the therapeutic test, will, as a rule, make the diagnosis clear.

Until all doubt is removed the case should be looked upon one of tubercular origin. Diagnostic difficulties are often produced by extensive hydropic joint effusion. Particularly in adults it will simulate chronic serous effusions from the presence of foreign bodies or the chronic effusion following trauma. Whereas the insufficiency of the treatment which is usually effective in the last-named conditions may give rise to a suspicion of the tubercular nature of the hydrops, a positive diagnosis can often be made only after joint aspiration or incision.

From *arthritis deformans* tubercular disease is easily distinguished by the chronicity of the former, the enlargement of the articular ends of the bones, and the tendency to osteophytic growth.

Prognosis.—The prognosis of tubercular arthritis depends very largely upon the treatment instituted and upon the degree of local disease when it first comes under observation. With proper treatment the disease may be arrested in its *incipiency*, and it is *possible for complete restitution to occur*. In the great majority of cases, however, the best that can be hoped for is a limitation of joint function, either from the partial obliteration of the joint-cavity or from the development of fibrous adhesions.

In the majority of cases, the cartilages having been more or less extensively destroyed, a complete fibrous ankylosis results and absolute restriction of motion exists. Occasionally, although recovery has apparently taken place, a small sinus will continue for months and even years, leading to a carious patch or an epiphyseal sequestrum, such as have been described in the pathology of the disease.

Treatment.—The treatment of tubercular arthritis must be based on the natural tendency of the disease toward recovery. With or without deformity such recovery ensues—in disease of the spine, for example, where operative interference cannot be resorted to early. *Conservatism*, therefore, must be the keystone of treatment, and only in the failure of this must resort be had to active interference.

Since tubercular arthritis is but the local expression of an infectious disease, general measures are not to be overlooked. An abundance of fresh air, a suitable diet, and attention to cleanliness are of first importance. The internal administration of *guaiacol* and of *creasote* has been found to be beneficial. In the hands of very many Continental surgeons the modified *tuberculin treatment* has also been followed by excellent results.

The *local* treatment of tubercular arthritis should, in the first place, be directed toward securing *absolute rest* to the joint. A prolonged rest in bed will often at once relieve pain and swelling, and even if prolonged through many months will not interfere with the nutrition of the patient. Local rest is best obtained by the use of a retentive dressing of plaster of Paris, of starch, or of silicate of soda, applied with sufficient snugness to distinctly compress the distended joint. In the joints of the lower extremity, except the hip, and of the upper limb, except the shoulder, and in tuberculosis of the spine, such retentive dressings are often the most serviceable of the methods of treatment to be invoked.

In the inception of the disease *traction* (extension) is also very serviceable, particularly in overcoming the tendency toward the contracture of the flexor muscles. During the acute stages such traction can be best maintained with the patient in the recumbent posture, whereas later some form of traction splints can be successfully used. In tubercular arthritis of the upper extremity the use of extension is far less valuable. When the contractures are firm enough to resist traction an open division of the contracted parts should be made.

In very many cases it is advisable to attack the tubercular disease directly by agents which distinctly destroy the bacillus or unfit its soil for necessary sustenance. Such agents are *zinc chloride*, *balsam of Peru*, and particularly *iodoform*. The direct injection of either of these agents

into a tubercular focus at intervals varying from four or five days to as many weeks will often obviate the necessity of a more or less crippling operation. The zinc chloride may be used in the saturated or 50 per cent. solution, and from four to five minims injected. The balsam of Peru is injected undiluted. The iodoform may be employed in 10 to 20 per cent. solutions in sterilized glycerin or olive oil, and injected in quantities varying from one drachm to two ounces. To avoid iodoform intoxication it is best to begin with a smaller quantity. While the injections are being made the urine should be carefully examined, since the gravest result of such intoxication has been parenchymatous nephritis. The iodoform solution should always be *sterilized* by submersion of the iodoform during four days in a 1 : 1000 solution of corrosive sublimate; it should then be thoroughly washed in sterilized water. The glycerin, and particularly the oil, should also be sterilized by boiling.

The best results obtained by the iodoform-oil injections were those of DeVos of Leyden. Of 68 cases, 72 per cent. were discharged cured. The injection is made through a large trocar after preliminary incision through the skin. After whatever fluid may be contained within the joint has been expressed, the iodoform oil or glycerin is injected, and by manipulation brought in contact with all portions of the joint. The shoulder-joint is to be punctured half an inch below and behind the tip of the acromion; the elbow-joint, on the outer side of the olecranon and above the head of the radius; the wrist, below the styloid processes of radius and ulna, nearer the dorsal surface; into the hip the needle should be made to penetrate from behind and above the trochanter; the knee can be directly penetrated through the interarticular line on each side of the patella; and the ankle-joint is most easily reached through a point directly in front of the tip of the external malleolus.

When many fibrinous shreds come away through the cannula it is advisable to freely incise the joint, with proper aseptic precautions, and to thoroughly irrigate it with a saturated boric solution before making the iodoform injection. If need be, the incision can be sufficiently enlarged to make the operation exploratory, the incision being closed immediately after the injection has been completed. For the cure of a tubercular arthritis from three to twenty injections may be necessary, and the time required to effect a cure varies from two months to one year.

Hydrops tuberculosis will often disappear under rest and compression. In the failure of this, *aspiration* should be resorted to, and this be followed by the injection of carbolic acid or iodoform. The so-called *cold abscesses* require special attention in many cases, although when they are limited in size they may be allowed to take care of themselves. Through defective operative treatment, septic infection, which may rapidly be destructive to joint and life, has often been induced in the past.

Here also the injection of iodoform, after the preliminary tapping and irrigation, is frequently followed by a brilliant success. The size of the abscess is no indication of the extent of the lesion which gave it origin. Its walls are lined by a quasi-pyogenic (*pyophylactic*) membrane which, as Volkmann has shown, is studded with miliary tubercles. When the iodoform injection, after repeated attempts, has failed of success, the abscess should be thoroughly incised, its walls cleared of the tubercular lining with a sharp spoon or, what is preferable, the operator's finger wrapped in sterilized or iodoform gauze. This operation should be considered incomplete until the aperture of communication, which usually

though not always is present between the abscess and the joint interior, has been discovered, enlarged if need be, and the joint treated by injection.

These conservative measures will frequently fail of encompassing a cure or even of stemming the progress of the disease. In cases from the lower walks of life the conditions when first seen may altogether preclude conservatism. Operative measures of greater or less extent are then called for, the object of which is the *mechanical removal* of the tubercular tissues and of carious bone, and the procuring of a surgically clean wound with its natural tendency to immediate union.

Sometimes there can be detected in the head of the tibia, the femoral condyles, and the ulna a tuberculous nodule which can be removed through an incision that does not involve the joint. In the removal of such a nodule the chisel should be carried through sound bone, and as far as possible the infection of this from the tuberculous centre is to be avoided.

In the great majority of cases the operative treatment cannot stop short of a *free incision* into the joint, thus making it in a measure *exploratory*. Such free incision, technically termed *arthrotomy*, is, of itself, with proper precautions, devoid of danger. When thus thoroughly exposed the tubercular foci can be readily removed, and, if the procedure has not been too long delayed, without seriously affecting the outlines of the joint surface. This operation, known as *arthrectomy* or *joint erasion*, means the removal usually of fungous masses from the synovial membrane, of the encrusting and interarticular cartilages, so far as they may be diseased, of the synovial membrane and capsule, if need be, and of the evacuation with the chisel or sharp spoon of tubercular foci in the epiphysis. The operation is therefore, in reality, an *atypical resection*.

In joint erasions recourse should be had to *cutting* rather than to *scraping* instruments, since the danger of infecting the wound with tuberculosis is thereby reduced to a minimum. After the erasure has been completed sterilized iodoform is to be introduced into the wound, the articular wound closed by deep sutures, and the cutaneous wound in the ordinary way.

Drainage is ordinarily *not called for*, although when oozing has been checked with difficulty a silkworm-gut strand, drawn through the wound and to be removed with the first dressing, will answer well for drainage. Many surgeons pack the wound for two or three days with iodoform gauze, after which the sutures introduced at the time of operation are tightened.

Even the heads of the humerus and of the femur have thus been successfully freed of tubercular nodules and of their encrusting cartilage, returned to their respective sockets, and excellent results obtained.

A further advantage of arthrectomy is the ease with which the operation can be repeated if necessity arises, and the important fact that by not interfering with the epiphyseal cartilage the growth of the bone in length is not curtailed.

Resection for tubercular arthritis, formerly very extensively practised, is for good reasons less and less employed. Until the period of puberty has been reached a formal excision should rarely be performed, since the removal of the epiphysis is invariably followed by very great shortening of the extremity. It is only after arthrectomy, as above

described, has failed in children and in young adults that formal excision should be at all practised. In persons who have arrived beyond the age of puberty, the same objection not obtaining, excisions are more frequently to be made. At this period of life repair, so far as bone is concerned, is less easily accomplished, and the uneven surfaces which remain after arthrectomy might fail to unite; therefore—as in the knee, for example—we are sometimes compelled to make a formal excision in order to ensure the speediest recovery with a useful limb. As a rule, however, excision for tuberculosis of the larger joints should be *reserved for the correction of deformity* after the tubercular process has healed spontaneously or through the methods of treatment, operative and otherwise, above described. In tuberculosis of the wrist and of the foot total excision of the bones involved is to be resorted to rather than the excision of the tubercular focus and its evacuation by curette or chisel. It is particularly in these cases that operative infection of contiguous joints and of overlying tendon-sheaths is likely to occur. Even in the absence of such infection the shell of bone which is left after the *evidement* of the tubercular focus is filled with a clot which readily becomes infected, and in the contrary event is difficult of organization.

In severer cases of tuberculosis of the bones of the wrist, and particularly of the tarsus, *amputation* will often afford the patient the quickest and safest road to recovery. Amputation must likewise be resorted to at times in children in whom the tubercular and secondary suppurative processes have left the region of the joint riddled with sinuses and the bones destroyed over extensive areas. In the lower extremity such amputations must be made oftener than in the upper, but in both, with the improved surgical technique of recent years, the mortality following them has been reduced to a minimum.

Ankylosis.

This signifies, literally, a crooking of the joint. In a general sense it is reserved for *fixation* of the joint, with which there is often associated an angular deformity. The diseased process may be in the *joint proper*, in the *periarticular tissues, the overlying muscles and tendons*, or even in the *integument*. Every joint fixation has thus often been included in the term ankylosis. A division has likewise been made into the *fibrous or false*, and the *bony or true*, ankylosis. A better division is that by which the term (*a*) *contracture* is used to designate joint fixation by abnormalities of the soft parts, and (*b*) *ankylosis from fibrous* or *bony union* of the articular surfaces proper.

a. **Contractures.**—Acute inflammations of the joints and tubercular processes are, as we have seen, very often early associated with muscular contraction, which, from the inception, immobilizes the joint absolutely except to examination under anæsthesia. After the subsidence of the primary disease the contraction may continue and simulate the locking of the joint. The *periarticular swelling* and the thickening of the capsule attending rheumatism will often leave a joint in a similar apparently ankylotic state. The *cicatricial contraction* which follows severe *burns* may likewise produce an apparent ankylosis. In the last-named condition the interior of the joint may remain, except for dryness, com-

paratively normal. The continuation of joint fixation of this nature will slowly, by the growth of new connective tissue from the periphery of the joint, eventually lead to a true ankylosis. In cases of severe *spastic paralysis* the condition of ankylosis is likewise simulated.

b. **True ankylosis** has been properly divided into the *fibrous* and the *osseous*, although in long-standing cases a combination of both forms will be usually found, and only in very chronic cases does it ever come to a complete bony union of the articular ends with total obliteration of the

FIG. 248.

Bony ankylosis of hip (original): external view of specimen shown in Fig. 247.

joint-cavity (Figs. 248 and 249). The diseases which are most productive of the true ankylosis are—*acute suppurative arthritis*, to a less extent *tubercular disease*, and *chronic rheumatism*. In the latter ankylosis of many joints is often seen. *Post-gonorrhœal arthritis*, the non-suppurative complications of *puerperal septicæmia*, and the *acute infectious diseases* are less often followed by bony ankylosis.

In considering ankylosis it is important to differentiate between that which is associated with deformity and that in which the joint is fixed in the most favorable position for usefulness (Figs. 250 and 251). In the shoulder, through the mobility of the scapula, this differentiation is not important; in the elbow an ankylosis may be said to be favorable when it is nearly at a right angle; in the hip and knee, when fixation occurs in the extended position.

The DIAGNOSIS of the conditions which fix a joint is ordinarily easily made. That of fixation from extra-articular causes must always be differentiated from that of true ankylosis. The clinical history of the case and the condition of joint movement under an anæsthetic would make the recognition simple. The differentiation between the fibrous and the bony ankylosis is, as a rule, also easily established. A bony ankylosis will absolutely prevent joint motion, whereas in the fibrous varieties the

patient himself or with a little assistance can always elicit a certain degree of motion. The knee forms an exception to this rule: notwithstanding an *osseous ankylosis*, some degree of motion can be elicited.

FIG. 249.

Bony ankylosis of knee (original).

The writer has in two cases seen an osseous ankylosis of the patella to the anterior surface of the femoral condyle with slight joint motion. The operation revealed the joint interior free except where the patella had formed attachments.

TREATMENT.—The treatment of joint fixation necessarily varies with the conditions which produce it. If the result of cicatrices, fascial or muscular *contractures*, attention must be directed to them rather than to the joint itself. The former must be remedied by plastic operation. Contractures of muscle and fascia can often be overcome under an anæsthetic. If this fails, success must be expected from a division of the tendons and fascia, either by subcutaneous operation or, preferably, by open division.

In cases of true ankylosis that are known to be fibrous, operative measures are called for only after a milder treatment by baths, massage, and active and passive joint movements has been tried without effect. Mechanical appliances to stimulate motion may also be tried. Very frequently, indeed, by the combined use of massage and weight-extension, the deformity which so often accompanies ankylosis can be overcome. In the failure of these methods recourse may be had to *forcible breaking up* of the fibrous adhesions which fix the joint, always under an anæsthetic (*brisement forcé*).

The treatment must always be very guardedly applied, and never until the disease producing the ankylosis has subsided. Untimely forcible disruption of adhesions will not infrequently be followed by a return of the acute disease which produced them, and often with greater severity. Nor should it be early resorted to for post-tubercular ankylosis or that following gonorrhœa or acute suppurative arthritis. Limbs and lives have often been sacrificed to the untimely use of forcible relief of ankylotic deformity. It is a wise precept to never completely overcome a great angular deformity from fibrous union at one sitting, however strong the temptation may be to at once give the limb its normal conformation.

The less the number of adhesions broken up at a sitting, the less is the reaction; therefore anæsthesia may be resorted to at intervals of a week or ten days, and thus gradually the deformity be overcome and an opportunity given for the little that is gained each time to be maintained. By this method there is avoided the danger of *lacerating* a large *vascular* or *nerve-trunk* running in close proximity and adherent to the joint-capsule. Particularly in attempting to overcome long, old-standing angular ankylosis of the knee have *ruptures of the popliteal artery*, vein, or accompanying nerve-trunk been produced. In severing adhesions the force should *always be so applied at first as to increase the deformity.* The angle of flexion of the knee and elbow should by the first movement be even more reduced. Upon this flexion should follow the first attempt at extension. Unfortunately, even with the most careful and oftenest repeated attempts to overcome a fibrous ankylosis, *failure* to restore, even approximately, normal joint

Fig. 250.

Bony ankylosis of hip with deformity.

Fig. 251.

Bony ankylosis of hip with deformity (original).

function is the rule. The fibrous bands which have been broken up reunite and the ankylosis is speedily re-established. If, therefore, the ankylosis is left in the most favorable possible position, it is all the patient can hope for.

The treatment of bony ankylosis must be limited to the correction of the deformity. When bony ankylosis has occurred and the disease which produced it has disappeared, the danger of operative interference is only that which would follow a like operation upon a healthy bone. The cumbersome appliances which in former years have been resorted to for overcoming osseous ankyloses are no longer to be used. The osteoclast, which played an important rôle before the days of antiseptic surgery, is only of historic interest. If the position of the limb is a correct one, osseous ankylosis is not to be interfered with. In the overcoming of deformity the operation may be done through the joint or in close proximity to it. In ankylosis of the hip, in which there is often extensive new bone-formation, it is better to divide the bone below the trochanter. When the neck of the bone has not been destroyed by disease, its *subcutaneous* division with a saw, after the method of Adams, may be resorted to. In ankylosis of the knee recourse must usually be had to the excision of a wedge, with base anterior, before the deformity can be corrected. Bony ankylosis at the elbow is best treated by excision, which will leave a very serviceable although an abnormally movable joint.

CHAPTER XXXIV.

OPERATIONS ON JOINTS.

BY JOSEPH RANSOHOFF, M. D.

General Considerations.—Injury and disease very frequently necessitate operations on joints. In degree they may vary from the puncture with the trocar, or the simple incision for establishing drainage, to a complete removal of all the structures entering into the composition of the joint. Whatever the operation may be, the greatest attention must be paid to the rules of surgical cleanliness, for in no other department of surgery have the beneficent influences of modern wound-treatment been better displayed than in operations upon joints.

Arthrotomy.—By this term is meant an incision into the joint, either for the purpose of establishing drainage or for purposes of exploration. It is indicated in chronic serous and purulent effusions where other measures have failed. For the removal of foreign bodies and loose cartilages, arthrotomy offers the only radical relief. Since the operation is always to be done under anæsthesia, the incision through the integument and the capsule should be ample enough to freely permit thorough exploration of the joint interior.

Arthrectomy.—Arthrectomy, or **joint erasure**, reserved almost altogether for the treatment of tubercular processes, has for its preliminary step an arthrotomy. The operation consists of the *removal of the synovial membrane, of the encrusting cartilages*, and of the *superficial laminæ of bone so far as they may be diseased.* In an arthrectomy, or joint erasure, *nothing is sacrificed except that which is the seat of disease.* The operation is therefore less severe than is an excision, can be performed earlier, and when successful may retain much of the joint function for the patient. To be entirely successful the incision into the joint must be large enough to permit its thorough exploration, lest a hidden focus of disease escape detection and appropriate treatment.

With experience an operator soon learns to discover an epiphyseal focus under an, as yet, intact cartilage, but one that is somewhat discolored from deficient nutrition. The advantage of arthrectomy is that it permits repeated operations, and in the event of its final failure still leaves to us the major procedure of excision.

Resection or Excision.—Although these terms are used synonymously, the former applies to the *removal of portions of bone in their contiguity*—the latter to the *removal of the articular surfaces and soft parts* that enter into the joint formation. Since the latter complete operations are not often demanded, the terms may properly be considered synonymous.

Joint excisions are called for in *compound dislocations* when reduction cannot be otherwise made, in *gunshot injuries* where there is much shat-

tering of bone, and for the *relief of angular ankylotic deformities. Suppurative processes* consequent on penetrating wounds or general septic infection likewise demand resection. The great majority of cases in which joint excision is demanded belong to the class of *tubercular arthritis.* The indications for the operation in this class of cases have been considered in the paragraphs on *tubercular arthritis* in the preceding chapter.

Excisions made for *injury* are, like amputations, divided into the *primary,* the *intermediary,* and the *secondary,* the first of these being made within the first twenty-four or thirty-six hours and before wound-infection has occurred. *Wherever possible excisions for injury should be primary.* The *intermediary* excisions are made during the height of infective inflammation, and consequently of the general septic infection. It is for this reason that the mortality of these operations on the larger joints is enormously high. *Secondary* excisions are made after the decadence of the infective process, and have for their object the removal of dead bone and of pyogenic surfaces, and such preparation of the articular ends as will ensure an ankylosis in a good position.

Arthrodesis.—Allied to the excision of a joint is the procedure which contemplates its *destruction and the production of an ankylosis.* The operation having this for its object is termed *arthrodesis,* and is applicable especially in cases of infantile paralysis, in consequence of which the usefulness, particularly of the knee and often of the ankle, has been lost. When in these cases orthopædic appliances fail to give relief or the financial condition of the patient precludes his obtaining aid therefrom, joint excision often restores the usefulness of the limb.

Bone resections are sometimes made as preliminary steps to other procedures. Segments of the skull, for instance, are temporarily removed with a flap, for intracranial operations, portions of the upper jaw are temporarily removed for operations upon the nasopharynx, and the patella is sometimes temporarily divided for operations on the knee. Such operations are called *osteoplastic resections.*

In excisions of joints the incision should be as nearly linear as possible; tendons should be preserved in their attachments to the soft parts, and bruised as little as possible. Attention to the making of a clean wound is one of the essentials of healthy repair. Since the labors of Ollier of Lyons and the younger Langenbeck of Berlin and Larghi of Bologna, much attention has been given to the *saving of the periosteum* as a single layer, which, subsequently ensheathing the denuded bone surfaces, is believed to further the development of new bone to take the place of that which has been removed. The *subperiosteal method,* as this has been designated, is feasible only in cases of disease where the thickening of the periosteum permits its being stripped away from the bone before it is divided. In these very cases, however, mostly of tubercular character, the saving of the periosteum is associated with the dangers of an incomplete operation and recurrence of the disease. In the traumatic cases of adults the separation of an unbroken periosteal layer is quite impossible. Furthermore, the regenerative power of the periosteum, except in children, has been overrated. The advantages of a subperiosteal excision are therefore doubtful.

Large blood-vessels are never endangered in excisions; the use of the Esmarch bandage is therefore unnecessary. The bleeding is ordinarily

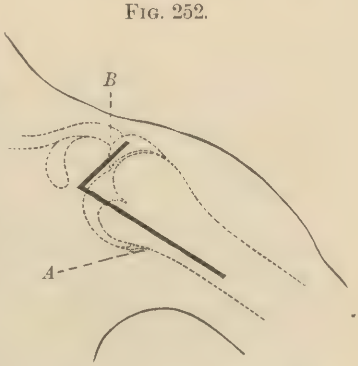
so slight during the operation that with competent assistance it does not obscure the field of operation nor make the overlooking of a nidus of disease probable. Besides the ordinary *instruments* required, there are necessary for excisions large retractors, an assortment of straight and grooved chisels, a variety of saws and of bone-cutting forceps, and gouges. Except in the shoulder and in the hip the wound can ordinarily be fully closed without drainage. The post-operative oozing can be reduced to a minimum by at once placing the limb at a right angle to the body and keeping it there for twenty-four hours: thereby the afferent circulation is rendered more difficult and the efferent facilitated. In order to fix the divided bones closely to each other many operators resort to *bone-suture* or the insertion of *steel* or *ivory pegs.* All of these procedures are, for the most part, superfluous. After the operation of excision has been completed and the ordinary dressing applied a retentive dressing or splints are at once to be used in order that the limb may be retained in the desired position from the very beginning. After joint excisions, properly made, the first dressing need not be changed before the end of from two to four weeks.

SPECIAL EXCISIONS.

Shoulder.

Resection of the shoulder is ordinarily partial, in that the head of the humerus alone is removed, the glenoid head of the scapula being usually left *in situ.* The operation can be made by a straight incision over the anterior surface of the joint, beginning at the acromio-clavicular junction and passing over the anterior convexity of the joint for a distance of three to four inches. (*Vide* Fig. 252.) The incision may likewise be made from a point above the coracoid process obliquely across the front of the joint in the direction of the fibres of the deltoid muscle. Charles Bell and Morel practised a U-shaped incision with the concavity upward, making a flap of the deltoid muscle. König exposes the joint through a posterior longitudinal incision.

Fig. 252.



Excision of the shoulder (Ollier): *A*, regular incision; *B*, supplementary.

The U-shaped incision, while disastrous to the deltoid muscle, affords better than any other method a thorough inspection of the joint interior and the removal of the capsule when this is necessary for tubercular disease. The anterior straight incision leads directly upon the long head of the biceps, thus permitting it to be drawn to one side and saved. The oblique incision secures the safety of the circumflex nerve.

Whatever the incision, the capsule is opened, the wound margins separated by broad retractors, and, while the assistant rotates the arm outward, the knife is carried over the lesser tuberosity, dividing the cap-

sular ligaments and the attachments of the subscapularis muscle. The arm being then rotated inward, the attachments of the supraspinatus, infraspinatus, and teres minor are divided. Wherever feasible in this step of the operation, the practice of Vogt should be followed of retaining the greater and lesser tuberosities with the muscular attachments. The head of the humerus is now forced out through the wound, seized with the forceps, and removed with the saw. The best functional results are obtained when the section is made through the anatomical neck. The line of section must be determined, however, by the extent of the lesion which demands the operation. This is completed by the removal, if it be necessary, of the glenoid fossa with saw or forceps, although in this event the attachment of the long head of the biceps to its upper end should be preserved in connection with a few bony laminæ with the periosteal covering.

AFTER-TREATMENT.—When there has been much oozing a puncture through the posterior wall of the joint should be made for drainage. The natural position of the arm by the side of the body, with the forearm over the chest, is the one to be maintained until consolidation has taken place. A splint is ordinarily not required.

RESULTS.—Excisions for gunshot wounds, collected by Culbertson, in 855 cases give a mortality of 31.44 per cent.; Otis's tabulation of 951 cases gives a mortality of 39 per cent. Almost all of these cases were tabulated in the pre-aseptic period. There were, according to Culbertson, 101 cases of excision for disease, with 16 deaths, or 15.84 per cent. The improvement following modern methods is shown by statistics, which, though not large, are conclusive. In Volkmann's and König's clinics 15 excisions of the shoulder were made—for injury in 2 cases, in 13 for disease—without a death. The usefulness of the arm after shoulder excision is ordinarily very good, although there is a tendency toward preternatural mobility. When the excision is made as low as the surgical neck a flail joint is very likely to remain. The best results follow the so-called subperiosteal excisions of Langenbeck and Ollier or the subcapsular operation of Vogt.

ELBOW.

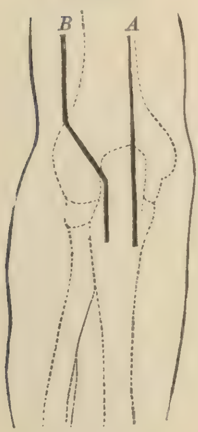
INDICATIONS.—Partial or complete excision of the elbow must be resorted to for compound dislocations, ankylosis, suppurative arthritis, gunshot injuries, and chronic articular disease. It is likewise indicated in chronic dislocations in which milder operations, like osteotomy of the olecranon, fail to make reduction possible.

In rare cases of symmetrical dislocation of the elbow, of which the writer saw one case from a fall, an operation should be performed on one side only to make the ankylosis of the two sides at different angles, thereby assuring the patient the greatest range of movement. Such symmetrical ankylosis has been described by Continental writers as following acute infectious diseases.

The various METHODS of operation have in common a long posterior incision, to which, according to various operators, may be added a parallel lateral incision, a transverse incision, or both. In almost all cases the posterior longitudinal incision suffices (Figs. 253, 254, 255). It should be in adults at least four inches long, with its centre opposite the base of the olecranon. The incision should run a little to the inner side of the axis of the olecranon and be carried along its entire length down to the bone. The soft parts—and, if possible, the periosteum—are first elevated toward the inner condyle by longitudinal incisions carried down to the bone. In this manner the ulnar nerve is pro-

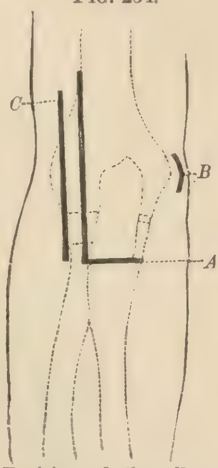
tected. The incision is carried around the epicondyle, carefully preserving, if possible, its muscular and ligamentous attachments. The dissection is next carried in the same way toward the outer condyle, equal attention being given to the protection of its muscular and ligamentous connections. Particular attention should here be given to saving the anconeus muscle. Through forced flexion the lower end of the humerus is then dislocated into the wound and sawed through on a level with the base of the condyles. The radius and ulna are next

FIG. 253.



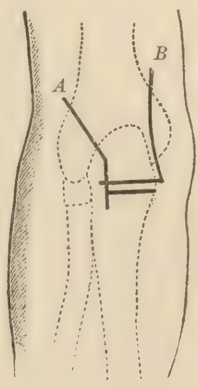
Excision of the elbow-joint: *A*, Von Langenbeck; *B*, Ollier.

FIG. 254.



Excision of the elbow-joint: *A*, Nélaton; *B*, *C*, Hueter.

FIG. 255.



Osteoplastic method: *A*, by external incision; *B*, Von Mosetig-Moorhof.

brought into the wound, and, if need be, divided on a level with the base of the coronoid process of the ulna. When the dissection is made for bony ankylosis the bones of the forearm must be divided first, and with them there is brought through the wound the lower end of the humerus, which is divided below the epicondyle. Ollier employs a "bayonet" incision, which is a modification of the external lateral incision advocated by Chassaignac. The incision begins on the external border of the arm, three inches above the articular line, and is placed between the supinator longus and the outer border of the triceps tendon. It is carried down to the level of the epicondyle, when it turns downward and inward to the olecranon, the posterior border of which it follows to its base and onward as far as need be toward the ulna. The incision over olecranon and ulna is at once carried to the bone. In the upper portion of the incision the periosteum is reached between the supinator longus and triceps and the capsule opened. In the middle portion of the incision the cleft between triceps and anconeus is followed, and the triceps tendon separated from the olecranon. After the detachment of the external lateral ligament the lower end of the humerus is dislocated outward and removed with a saw. Radius and ulna are subsequently removed in the same way. The ulnar nerve is not seen in this operation.

The After-treatment.—The position preferable after excision of the elbow is that of slight flexion, with the hand in pronation. Fixation should be achieved by wooden or metallic splints, or preferably with a bracketed plaster-of-Paris dressing. A right-angled position ought not be given the arm, since the resected ends are thus most separated from each other, and the tendency to a flail joint is thereby given. Passive movements of the wrist and of the fingers should be made early; those of the elbow likewise, particularly in young people, in whom the formation of a new and useful joint is probable. On the other hand, when in adults the extent of the excision precludes so favorable a result, and a flail joint is likely to result, passive movements should be for a long time refrained from.

Results.—According to Culbertson, the mortality of partial excisions for gunshot injury is 26.75 per cent.; of total excision, 25.32 per cent. For other than gunshot injuries partial excisions show a death-rate of 7.40 per cent.; total excisions, 21.5 per cent.; partial excisions for disease, 11.11 per cent.; total excisions for disease, 9.93 per cent. These statistics are nearly those of Otis obtained from cases in the Civil War, and of the German wars as tabulated by Gurlt. All of these statistics are of pre-antiseptic days. Most of the deaths have resulted from infection. Middledorpf tabulated 321 excisions of the elbow, of which 304 were for tubercular arthritis. Wound-infection produced no death: 28 (9.21 per cent.) died of phthisis, 14 (4.6 per cent.) of intercurrent disease—mortality, 31.81 per cent. The statistics of König's clinic are similar. Of 83 cases, 4 died soon after the operation—1 of iodoform-poisoning, 1 of pulmonary phthisis, 1 of bronchopneumonia, and 1 of diphtheria; 26 ultimately died of phthisis. Of 163 patients upon whom excisions of the elbow had been done, and which were observed on an average for nine and a half years, death resulted in 21.48 per cent. from tuberculosis and amyloid degeneration. The functional results of excisions of the elbow are generally very good. Even when a flail joint results the arm can be made very useful by properly constructed prosthesis. In very many cases there is a quite extensive bone-repair, a new joint being sometimes formed, such cases having been described by Textor, Roux, Doutrelepont, and Billroth. Nepveu has recently collected 21 cases of this character. The general form of the new joint approximates that of the ankle, as a consequence of which flexion and extension are easily performed, and even pronation and supination may approach normal limits.

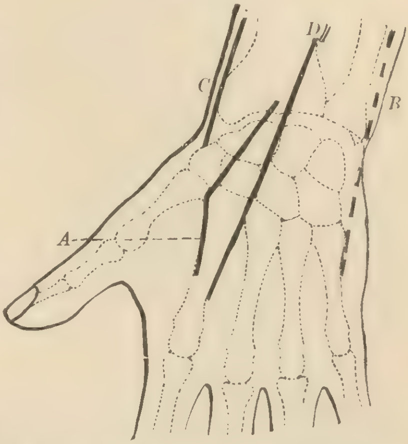
The Wrist.

The complexity of the wrist-joint, the number of bones entering into its formation, the firmness with which they are held in relation to each other, and the number of the overlying tendon-sheaths have made operations on it difficult of accomplishment. Post-operative extension of the disease, protracted suppuration, and a result which is, as a rule, far from good, have made many operators question the usefulness of excisions. With improved technical resources, however, better results are being obtained, and particularly after partial excisions, and to a considerable extent after total excisions, a hand that is fairly useful may be retained. An excision should be considered complete only when at least the extremities of the bones of the forearm and all of the first row of the carpus, with the possible exception of the pisiform, are removed. Any operation short of this should be designated a partial excision. The conditions requiring excision are gunshot injuries, compound fractures of civil life, suppurative arthritis, and tuberculosis. In the complicated injuries of the wrist and hand as sustained in factories, and as often seen in civil life, partial and informal excisions should always be given preference to primary amputation, unless it is evident from the complicated nature of the trauma that gangrene would follow. It is particularly in this class of cases that conservative resection is followed by excellent results in cases apparently hopeless. For disease, resection

is rarely called for before puberty, the cases being amenable to the milder measures of removal of individual bones. It is during the third and fourth decades of life that excision is most frequently demanded.

METHODS.—The operation most frequently performed by English and American surgeons is that described by Lister in 1865 (Fig. 256). The incision begins over the middle of the dorsum of the radius on a level with the styloid process. It is carried downward in the direction of the inner edge of the joint of the thumb and first metacarpal bone, from which point it is deflected downward in the long axis of the latter to about its middle. This, which is known as the radial incision, divides only the tendon of the short radial extensor of the wrist. The tissues upon the radial side of the incision are raised, the tendon of the long radial extensor of the wrist is divided at its point of insertion, and all the soft parts are retracted outward, thereby exposing the trapezium, which is cut off from the rest of the carpus, but left in place to be removed later. By extending the hand the tendons are relaxed and the carpus cleared in the direction of the ulnar border of the hand. A free ulnar incision is then made, the knife being entered two inches above the styloid process of the ulna directly in front of the bone, and carried downward between it and the flexor carpi ulnaris in a straight line as far as the middle of the fifth metacarpal bone on its palmar surface. The dorsal lip of this incision is then raised, the tendon of the extensor carpi ulnaris cut at its insertion and dissected up from its groove in the ulna. The extensors of the fingers are then lifted up and the dorsal and internal lateral ligaments of the wrist-joint divided. The flexor tendons are next separated over the front of the carpus, to accomplish which the unciform process of the unciform bone must be cut with the forceps. In this dissection the knife ought not to be carried below the bases of the metacarpal bones, to avoid injuring the deep palmar arch. The anterior radio-carpal ligament is then divided, the carpo-metacarpal articulations opened, and the carpus is extracted through the ulnar incision with suitable sequestrum forceps. The ends of the radius and ulna can then be easily protruded through the ulnar incision, and as much as may be necessary can be removed with gouge, chisel, or saw. The ends of the metacarpal bones are sawn off or at least deprived of their articular facets. The operation is completed with the removal of the trapezium, which, being seized with a strong pair of forceps, is readily dissected out without necessitating the division of the radio-carpal flexor or the radial artery.

FIG. 256.



Excision of the wrist: *A*, Lister's radial incision; *B*, Lister's ulnar incision; *C*, Ollier; *D*, Von Langenbeck.

Continental surgeons, following the lead of Maisonneuve, Boeckel, and the younger Langenbeck, usually resort to a single dorsal incision placed midway between the extensor tendons or nearer the radial ulnar border. Langenbeck's operation with a single incision has given excellent results. In a large hand it should be at least $4\frac{3}{4}$ inches in length, or extend nearly 4 inches below the joint line and $1\frac{1}{2}$ inches above it. The incision is straight, and is placed in the interval between the extensor indicis and the extensor secundi internodii pollicis, closely following the radial border of the first of these tendons. The incision being carried down to the bone, the unopened sheaths of the tendons, with the periosteum and the overlying soft parts, are lifted from the bone with the elevator, first to the radial and then to the ulnar side of the incision. The hand being flexed, the articular surfaces of the first row of the carpus are exposed and the bones removed together or individually. The lower end of the radius and ulna can now be easily protruded through the wound and treated according to the conditions found. The operation is completed by the removal of the second row of the carpus and the bases of the metacarpal bones. Vogt ensures free movement for the extensor tendons by chiselling away a thin lamina of bone with the periosteum from the dorsal side of the radial epiphysis.

AFTER-TREATMENT.—Drainage is usually demanded after excision of the wrist. The hand and forearm should be maintained upon a well-padded splint in dorsal flexion, the fingers being slightly flexed. The splint ought not project beyond the palm of the hand, early movements of the fingers being essential to a useful hand. During the first twenty-four or forty-eight hours the entire limb should be kept suspended to reduce the post-operative oozing to a minimum. Active movements of the fingers should be instituted as soon as it can be done without pain.

The RESULTS of this operation are not very satisfactory, although better than those of amputation. Culbertson collected 182 cases, of which 66 were done for gunshot injury, 16 for other injuries, 85 for disease, and in 15 the results were incompletely given. Of the 85 cases for disease, 51 were partial excisions, with a mortality of 15.69 per cent.—33 total excisions with a mortality of 6 per cent. The relative mortality was 15 per cent., 12 per cent., and 11.76 per cent. The cases were collected prior to 1874. Of 79 cases of excisions for disease, in 10 secondary amputation was required, in 6 the results were described as perfect, and in 36 the hand was useful. Of 6 cases operated upon by Billroth of which the result is known, only 1 case was permanently cured, and 3 died of phthisis. Of 33 cases treated by operation conservatively in 21, death resulted from phthisis in 10. Fahrenbach has recently reported on 28 excisions of the wrist for tuberculosis made by König: 16 resulted in complete cure; 3 retained fistulæ which did not interfere with the usefulness of the hand; amputation had to be resorted to in 1; in 5 the results were unknown. In only 3 of the 19 cases of recovery was the hand nearly useless.

THE FINGERS, THUMB, AND METACARPUS.

Formal excisions of the bones and joints of the hand, although formerly described in works on operative surgery, are rarely required. The operations are for the most part limited to the removal of necrotic sequestra or of fragments in compound wounds of the fingers and hand. The formal excision of the metacarpal bones, with the possible exception of that of the thumb, will usually leave a flail-like finger, which may become a source of inconvenience to the extent of necessitating a second-

ary amputation. Therefore, as a rule, with the exception of the thumb, the formal excisions of phalangeal or metacarpo-phalangeal joints of the hand are largely tentative. In most cases primary amputation is to be preferred.

The Hip.

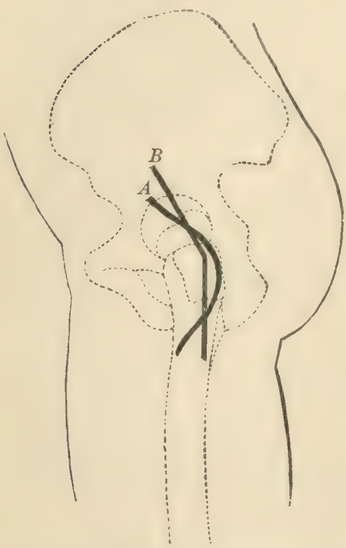
Excision of the hip is almost always limited to the removal of the head of the femur and more or less of its neck. It has been performed for gunshot injuries, suppurative disease, and particularly for tubercular arthritis. Otis, from the statistics of the Civil War, maintains that primary excision is indicated in uncomplicated cases of shot fracture of the hip, and that secondary operations are called for where the diagnosis has not been made early and in secondary involvement of the joint. The disastrous results following excision in the Franco-German War led Langenbeck and other German surgeons to promulgate conservatism in injuries of this character. The recoveries following conservatism were 25 per cent., the deaths 63 per cent.; primary excision was followed by a mortality of over 90 per cent. With improved antisepsis and asepsis it is probable that future wars will witness a very decided reduction in the mortality of operative interference after shot fractures of the hip.

The operation is indicated in tubercular arthritis when, notwithstanding conservative measures, the destruction of the joint progresses and the vitality is undermined by long-continued and profuse suppuration. As will be seen from the chapter on tubercular arthritis, a formal excision should be reserved for extreme cases, and particularly in children and in youths below maturity should the operation be limited to the removal of diseased structures, the operation being made an atypical resection or an arthrectomy. The excision of the entire epiphysis of the femur in a growing child means a shortening of from five to six inches when the subject has reached full development. In patients past the fifteenth year and in adults the same limitations do not exist, and formal excisions can be oftener made. Excisions are likewise called for in rare cases of arthritis deformans, for bony or fibrous ankylosis where simple osteotomy has not availed. Old-standing and painful dislocations of the hip and congenital dislocations may likewise call for operations upon the hip, although in the latter condition an osteoplastic operation looking to the formation of a new acetabulum should be given the preference over the removal of the femoral epiphysis.

Methods.—The simplicity of the hip-joint makes it approachable for operative interference from all sides except the inner. Many methods of excision have therefore been suggested and practised (Fig. 257). Longitudinal, curvilinear, and transverse incisions have been recommended for opening the joint, and flap operations with upper or lower convexity have likewise been practised. Of the various incisions, the longitudinal are unquestionably those best adapted for saving as much as possible of the ligamentous and muscular structures. The more complicated the incision, the greater the wounding of the soft parts and the less the probability of a good primary result. The longitudinal incision that is most often practised is that originally made by White,

but now known as the Langenbeck incision. The patient being placed upon the sound side, the limb, if it be not already so from disease, is flexed at an angle of 45°. An incision from three to six inches in length, according to the age of the patient, is made over the centre of the trochanter and in the axis of the femoral shaft. It should begin just above the trochanter, and in its upper two-thirds be placed in the gluteal region. Over the trochanter the incision passes at once to the bone, whereas the gluteal muscles are divided layer after layer. When the capsule is reached it is divided in the direction of the original incision from the acetabular margin to the femoral neck. Two transverse incisions made close to the acetabulum by cutting the cotyloid ligament and admitting air into the joint will open this freely for inspection and manipulation. The muscular attachments to the great trochanter are next divided close to their insertion, the periosteum as far as possible being preserved. The limb is rotated inward to expose and facilitate the divisions of the posterior muscles, and rotated outward to divide the anterior. The capsule being freely divided, the head of the femur is readily dislocated and brought into the wound. The ligamentum teres, having usually disappeared, demands no attention; when present it must be divided. The soft parts being thoroughly protected by retractors, the saw is applied at the base of the femoral neck or, if need be, at the base of the trochanter. A very serviceable method is that of dividing the femoral neck at its base with a chisel, and subsequently removing the trochanter, if need be, with a saw. Wherever possible the trochanter should be saved. The operation is completed by removing the foci of disease from the acetabulum with bone gouge or chisel. As much of the capsule as can be should be removed and all of the joint interior cleansed with a sharp spoon or the finger covered with gauze. Before closing the wound the sinuses which are present should be thoroughly opened up or scraped. Tubular drainage being provided for, the wound is closed with sutures.

FIG. 257.



Excision of the hip: *A*, Sayre; *B*, Ollier.

Operation by Anterior Incision.—Luecke and Schede, and more recently Barker, have employed an anterior incision. It begins below the anterior spine of the ilium half an inch to its inner side, and runs downward and a little inward for three inches. It passes to the inner side of the sartorius and rectus femoris, and exposes the external border of the ilio-psoas. The further steps of the operation are similar to those above described, although the neck of the femur may be divided *in situ* with a keyhole or chain saw.

The incision of Barker is to be preferred. It is made near the external border of the limb, passes between the tensor vaginæ femoris and gluteal muscles on the outside and the sartorius and rectus on the inside, until it reaches the neck of the femur. The operation is simpler than that of Luecke and Schede, and closely resembles the incision made by Hueter. The position of an anterior incision sim-

plifies the use of a posterior splint and does not interfere with drainage. The advantages are such that English writers believe the method to be that which should always be practised unless contraindications exist.

The curvilinear incision, or its modification the angular incision, is made over the trochanter with the concavity looking forward. Sayre's and Ollier's operations are the best known of this class, although Velpeau had already performed one similar. Sayre describes his operation as follows: "Select a strong knife; drive it home to the bone at a point midway between the anterior superior spinous process of the ilium and the top of the trochanter, then drawing it in a curved line over the ilium and the top of the great trochanter, extending it, not directly over the top of the trochanter, but midway between the centre and its posterior border, and completing it by carrying the knife forward and inward. Make the whole length of the incision from four to six inches, according to the size of the thigh." In this manner a curved incision is made through all the soft parts down to the bone and through the periosteum. A second incision is made with a narrow, thick knife through the periosteum, only at right angles to the first incision on a level with the lesser trochanter or a little above it, and carried as far as possible around the bone in front and behind. Beginning at the angles of the two incisions, the periosteum is raised with the elevator and all muscular attachments severed before the saw is used. Sayre always divides the bone below the trochanter major.

Ollier has recently advocated an osteoplastic excision in which, through a curved incision with downward convexity made over the top of the trochanter, the latter is exposed and divided with the chisel, turned upward with a flap, and reunited by sutures to the femoral shaft after the excision of the neck and head has been completed.

The management of the trochanter in excisions of the hip should not be routine. Although, on the one hand, Sayre and Volkmann made it a rule to remove it with the femoral neck, on the other hand Langenbeck and Hueter have advised supratrochanteric excision wherever feasible. The latter operation necessarily is followed by the least degree of shortening. Circumscribed disease of the head and neck requires the removal only of these parts. Whenever it is necessary, on the other hand, to thoroughly expose the joint interior and the disease requires the removal of the synovial membrane and parts of the acetabulum, excision of the trochanter becomes necessary.

After-treatment.—In an adequately equipped hospital the patient can be placed in a wire cuirass, the limb in extension. A very effective dressing is the fenestrated plaster-of-Paris breeches, with extension by means of weight and pulley, as after the method of Gurdon-Buck. Counter-extension is not often required. Particular attention must be given to overcome the tendency to adduction, and many operators advise placing the limb from the beginning in slight abduction. Since in most cases fibrous or bony ankylosis is sought for, passive movements are not ordinarily to be employed after excisions of the hip. In the few cases in which, from the local conditions existing at the time of operation, the preservation of joint movement can be hoped for, passive movements should be instituted as soon as the wound is thoroughly united.

Results.—The mortality of excision of the hip for gunshot injury has already been considered. That following operations for disease has been placed by Culbertson in 426 cases at 43.84 per cent. for partial excisions, and 46.10 per cent. for complete excisions. The mortality due to the operation itself has been very largely reduced in the last two decades as a result of modern wound-treatment. From 86 excisions made in Strasburg, 6 died of collapse, embolism, or other causes attributable to the operation; altogether 37, or 43 per cent., succumbed, most of them from local recurrence or generalization of the disease. Of 120 cases which were observed for a number of years after the operation, 44 ultimately died from causes independent of the operation, and, as a rule, from local recurrence of tuberculosis or its development in the viscera.

The greatest mortality follows operations performed in the first five years of life. It decreases from that period on up to the full development. In operations

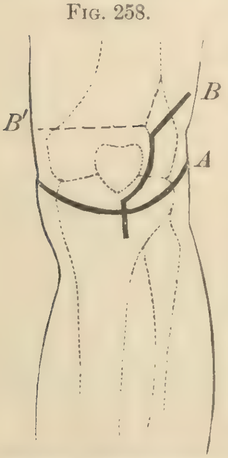
done in adults, and particularly in older subjects, the mortality is again very great. Regarding the usefulness of the limb after excision, the statistics of Baer show that in 8 out of 46 cases free active movement of the joint could be made; in 23 movement was limited, in 11 cases ankylosis resulted, and in 1 a flail joint remained; 12 were able to stand without support upon the resected limb.

The Knee.

Resection of the knee may be demanded for gunshot or other injury, for deformity, ankylosis, for neuropathic arthritis, and particularly for tubercular disease. Resection for gunshot injury has in past wars proved so fatal that unless the dangers of death from sepsis can be materially decreased, choice should be made between conservatism and amputation. The mortality following resection for gunshot injury is placed by all writers at about 90 per cent. For ankylosis with angular deformity resection is a safe and almost uniformly successful procedure. In tubercular disease the easy accessibility of the joint fits it particularly for the more conservative operation of arthrectomy and informal or partial excisions. In the failure of this recourse may be had to formal excision. The latter is not called for in young children, and even in youths and in adults should rarely be resorted to as the primary operation, except in cases of most extensive destruction by disease.

Methods.—The anatomical relations of the joint make it approachable by transverse, curvilinear, or longitudinal incisions made over the front and sides of the joints (Figs. 258, 259, 260). The transverse incision is made directly across the centre of the joint down to the patella, which is divided with the saw. The flaps thus made are reflected upward and downward, and the joint interior is reached. Usually the semilunar incision with upper concavity is resorted to. The knife, being entered at the posterior extremity of one condyle, is carried downward and forward below the patella across the patellar ligament near its insertion, and thence upward to the posterior end of the inner condyle. The incision is carried into the joint. The flap containing the patella, being grasped with a sharp retractor, is drawn upward by an assistant, the knee being flexed to a right angle. By transverse incisions the lateral ligaments are divided and the crucial ligaments are severed close to their tibial insertions. In this step of the operation, to avoid injury of the popliteal vessels, the point of the knife should be directed toward the inner condyloid depression. The articular ends of the femur and of the tibia are now sufficiently separated from each other to permit their free protrusion from the wound and, after periosteal decortication around the periphery, their removal with saw or broad chisel. When the saw is used the femoral epiphysis may be divided from before backward. To remove the upper end of the tibia it is advisable for the protection of the popliteal vessels to saw from behind forward. The operation is completed by the removal of the patella if it be involved in the

Fig. 258.



Excision of the knee-joint: *A*, semilunar incision; *B*, Ollier's incision.

disease, and the extirpation of the subquadricipital pouch. The extirpation of the capsule completes the operation. The proximity of the

FIG. 259.

FIG. 260.

Sections to show the position of the epiphyseal cartilage at the knee and the points at which the section ought to be made in excision (Stimson).

vessels makes the removal of the posterior wall of the capsule a delicate procedure.

E. Hahn and, following him, a number of operators have reversed the semilunar incision, giving it an upper convexity and dividing the tendon of the quadriceps femoris instead of the ligamentum patellæ. The advantage of the procedure is the ease with which the subtendinous pouch of the joint is reached. Volkmann and others open the joint by the transverse incision and the division of the patella, the latter being reunited, if it is to be saved, with catgut or wire sutures after the completion of the resection.

Moreau, Ferguson, Butcher, and Ollier employ an H-shaped incision, the horizontal portion of which is carried through the ligamentum patellæ. It has no advantage over the transverse or the curvilinear incision. When a longitudinal incision is made it may be in the axis of the limb and through the centre of the

patella, which is then divided vertically with saw or chisel. As in transverse divisions of the patella, suture may be practised after the excision is completed. Langenbeck made an incision upon the antero-internal aspect of the joint. The methods by longitudinal incision have only the doubtful advantage of leaving the ligamentum patellæ intact and serviceable in case joint function is retained. The division of the ligamentum patellæ by the transverse operation does not militate against equally good results, as has been shown after many arthrectomies, since prompt reunion follows its division. The method of sawing the bone varies with different operators. To prevent a tendency toward angular deformity, Watson, Kocher, Billroth, Fenwick, and others give the femoral end a convex and the tibial end a corresponding concave surface. To the same end Albert removes the articular ends step-fashion, leaving more of the femoral condyles behind and of the tibia in front. In an arthrectomy the patella should be retained. In an excision it should likewise be retained, since the ankylosis which it has a tendency to readily form with the femur distinctly prevents angular deformity. In every excision its cartilaginous covering should be thoroughly removed with saw or chisel, and if found diseased it should be removed in its entirety.

For *fixation* of the bone surfaces Gurdon Buck in 1853 resorted to bone suture. Many operators have since resorted to catgut or wire suture, or to the even firmer fixation by means of steel or ivory pegs. As a rule, such procedures needlessly complicate the operation, since fixation is readily maintained by closely applied retentive dressings and proper splints. With careful attention to hæmostasis during the operation drainage will be sufficiently provided by a strand of silk-worm gut passed through the most pendent portion of the wound. Ordinarily even this is superfluous.

After-treatment.—Accurate apposition of the bone surfaces is best maintained by means of a posterior concave splint, which is retained in place by plaster-of-Paris bandages applied above and below the line of incision. If desirable, the limb can be maintained suspended during the first twenty-four or forty-eight hours to reduce oozing to a minimum. When such a retentive appliance is used, it should be fenestrated over the wound to make the parts easy of access. When properly applied the first dressing need not be changed in less than from two to four weeks.

Results.—Immediate results of excision of the knee for tubercular disease are very satisfactory. A. M. Phelps has recently collected 329 cases of excision of the knee with antiseptic precautions, with 31 deaths, or a total mortality of 9.42 per cent. Of the fatal cases, 15 resulted from phthisis, 1 from ether, 2 from amyloid disease, 2 from nephritis; only 10 deaths, or 3.03 per cent., were due to the operation. Similar results were obtained in 84 cases operated on by Ashhurst. There were only 7 deaths, or a mortality of 8.3 per cent. Lossen tabulated 586 excisions, of which 439, or 75 per cent., recovered, 10 per cent. were discharged with fistulous openings, and 8 per cent. required subsequent amputation; 38, or 6.5 per cent., died soon after the operation. In approximately 75 per cent. of the cases, therefore, a permanent success is obtained from excision of the knee for tubercular disease.

In children partial excision and arthrectomy have given equally good results. Paoli reported 14 arthrectomies with 1 death, which resulted from general tuberculosis after amputation had become necessary. Miller of Copenhagen reported 42 operations, 2 of which were fatal after generalization of the disease. In 15 cases patients were free of disease during from six months to four years. In 26 cases there was a recurrence of disease; in 12 of these the recurrence was slight and permanently relieved by curetting. In 8 of the remaining cases atypical resection was demanded, and in 2 amputation. Of the arthrectomies, 18 were made in children, of which 7 could be observed from one to four years after the operation. In these there was no shortening. In 6 cases there was a shortening of from one to two centimetres. In 5 cases there was an elongation of from half an inch to an inch. In the smallest number of cases ankylosis followed the arthrectomy; the greater number preserved joints more or less movable. Angerer reported upon 82 arthrectomies, of which 63 were upon children under fourteen

years of age. In 10 of the cases there was a recurrence. In a very large proportion considerable joint mobility was retained.

The Ankle.

Excision of the ankle may be performed for gunshot injury or compound fracture, and particularly for compound dislocation. It may likewise be demanded in tubercular disease, although the protracted and doubtful recovery may in the cases of adults make amputation preferable. In its limited application excision of the ankle means the removal of the lower ends of the tibia and fibula and the upper surface of the astragalus. The complicated anatomical relations of the bones and joints of the tarsus will therefore make a formal excision for disease a rarity. According to Ollier, in three-fourths of all cases the astragalus is primarily and most extensively involved.

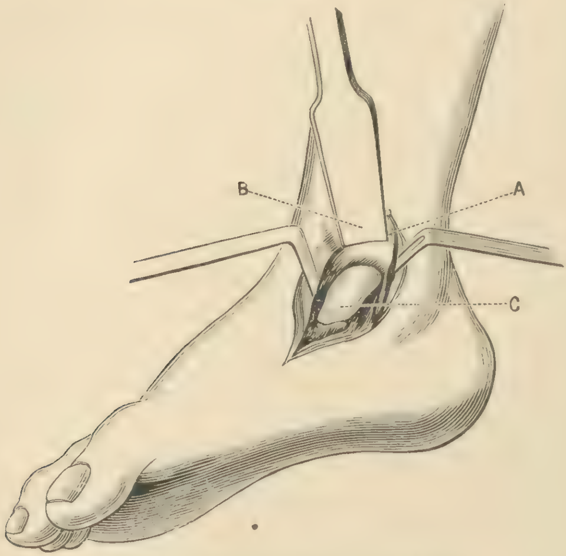
Methods.—Many methods have been devised for excision of the ankle, but they are mostly modifications of the original procedure of Moreau by reaching the joint through external and internal lateral incisions. In 1865, Langenbeck modified it for the purpose of making the operation subperiosteally. The external incision, about three inches in length, is made over the lower end of the fibula and its malleolus beyond its tip. The incision is carried down to the bone: by means of an elevator the fibula is separated from its periosteum and divided with a chain or keyhole saw an inch above its lower end. The lower bone segment, being grasped by forceps, is drawn out of the wound, turned from side to side, and with short cuts of the knife severed from its ligamentous attachments. In this step of the operation the external lateral ligament should be injured as little as possible. The second step of the operation, according to Langenbeck, is the removal with the saw of the upper articular surface of the astragalus. The third step is constituted by an incision over the internal malleolus, of equal length with the external, and likewise reaching down to the bone. The periosteum, being divided vertically, is peeled as far as possible from the inner and posterior surfaces of the bone. The internal lateral ligament is next divided and the tibia protruded through the inner incision by forcibly everting the foot. The articular end of the tibia is then removed with a saw. If need be, the whole of the astralagus can be removed from the external incision.

The supposed imperfect exposure of the joint interior through lateral incisions has led many operators to resort to more or less transverse incisions across the front of the joint, either dividing the tendons and subsequently suturing them, or partly cutting and partly forcibly retracting them during manipulations upon the joint surfaces. These methods are, as a rule, to be condemned. König in 1885 modified the operation by longitudinal incisions, placing them respectively over the anterior borders of the tibia and fibula (Fig. 261). From these two incisions all of the soft parts between them are raised as a flap from the anterior surface of the joint. This is now opened and the interior exposed. With a broad chisel the outer lamellæ of the malleoli, together with their ligamentous attachments, are severed. The soft parts being then retracted, the lower end of the tibia is divided with a broad chisel and removed with forceps. When it is the seat of disease the fibula is removed in the same manner. The astragalus is next cared for, its upper surface being removed with the chisel, or, if necessary, the bone is entirely taken away.

A unilateral external incision recommended by Chassaignac and Erichsen

gives valuable results if, after the opening of the joint and division of the external lateral ligament, the foot be forcibly dislocated inward. With almost the same object in view Kocher resorts to a semilunar incision from the outside of the tendo Achilles to the outer border of the extensor tendons and passing underneath the

Fig. 261.



König's incision for excision of the ankle.

external malleolus. The joint is thus easily and widely opened, the peroneal tendons alone being divided. After the completion of the operation these are readily sutured. This method is particularly applicable to children.

After-treatment.—The wound is closed after ample drainage has been provided for. Any tendency to a talipes-equinus position should be overcome by the use of a well-padded leg-and-foot-splint made of perforated tin, felt, or plaster of Paris. During the first twenty-four hours the limb is to be retained at a right angle, after which it should be kept suspended.

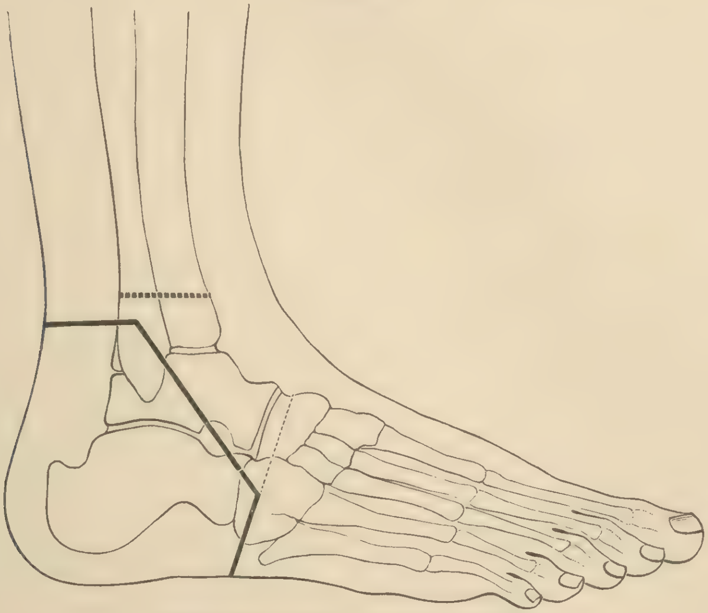
Results.—The mortality of excision of the ankle for gunshot wounds, according to Otis, is 33 per cent.—to Culbertson, 26 per cent. The results of excision for the injuries of civil life are only 12 per cent. Excision for disease has even a lower mortality. In 1885, König reported 32 cases, of which 11 were entirely cured and 5 retained small fistulæ; 16 cases, or 50 per cent., retained a useful foot. Of the remaining cases, 7 were subsequently subjected to amputation, and 5 were of too recent a date to warrant any conclusion as to the end result. Two died of intercurrent disease, and of the remainder the result was unknown. In 1891, Buntz of Heidelberg reported upon 25 excisions, of which 10 recovered and were observed from one to four and a half years. Death did not follow as the result of the excision in any of these cases. Ashhurst reports 10 excisions of tubercular disease of the ankle without a death due to the operation; 2 of the cases died subsequently of phthisis. In traumatic cases the operation is very satisfactory, and the results in tubercular diseases of children are also very good. In adults, particularly in patients from walks of life where the time required for recovery is an important factor in determining the method of operation, amputation must often be resorted to as the speediest means of affording relief.

Osteoplastic Excision of the Foot.

For tuberculosis of the ankle-joint and of the bones of the tarsus Wladimirov and Mikulicz, in 1871 and 1880 respectively, advised a pro-

cedure by which the ankle-joint and as many of the bones of the tarsus as may be necessary can be removed with the retention of the anterior por-

FIG. 262.



Osteoplastic excision of the foot (Mikulicz).

tion of the foot, which is fixed in an extreme equinus position. The operation is performed with the patient in the prone position. An incision is carried from the tubercle of the scaphoid bone across the sole of the foot to an inch behind the base of the fifth metatarsal bone (Figs. 262, 263). From each end of this incision another is made longitudinally to the base of each malleolus, the ends of the lateral incisions being united by a cut across the ankle dividing the tendo Achilles. All incisions having been carried to the bone, the quadrangular flap is dissected from above, the joint opened from behind, the lateral ligaments divided, and the astragalus and calcaneum separated from their attachments and removed. The lower extremities of the tibia and fibula and the articular surfaces of the scaphoid and cuboid are next removed with

FIG. 263.

Results of an osteoplastic resection of the foot.

the saw. The foot is then brought back, the divided surfaces carefully adjusted, and the wound closed. Wire suture or bone pins may be used to ensure fixation, although the procedure has been shown to be superfluous. Buntz has recently tabulated 34 cases of osteoplastic resection of the foot, in none of which death was attributable directly to the operation. Of 26 cases operated upon for tuberculosis, 18 were cured—11 with a very good and 7 with a useful foot; 2 died of tuberculosis, and in 5 a secondary amputation had to be made. The result in 1 was unknown. Of the remaining cases, the result in regard to usefulness was good in 4, fair in 3, and bad in 1.

CHAPTER XXXV.

SURGICAL DISEASES OF THE OSSEOUS SYSTEM.

BY ROSWELL PARK, M. D.

AT the very outset of a study of surgical diseases of the osseous system it is necessary to emphasize a fact which students and young practitioners are often prone to forget—namely, that bone, even the densest, is *a tissue*, and that as such it is liable to infection, suppuration, gangrene, etc., just as is any other tissue; that all infectious processes are identical in general character, their gross manifestations varying only by virtue of the peculiar characteristics of the tissue in which the infection occurs. Bone is always vascular, and even that exceedingly hard variety which is met with in the petrous portion of the temporal, or the ivory exostosis, has sufficient connection with the vascular system to permit of its proper nutrition. The firmest and hardest bone will bleed when divided or injured, and any tissue which will thus bleed can react injuriously to various irritants.

Bone is covered, except at joint ends, by a dense fibrous membrane—the *periosteum*—whose relations with it are very intimate. Inside the cranium the dura mater functionates in a double capacity—as a cerebral membrane and as an internal periosteum. Joint ends of long bones and joint surfaces elsewhere are *encrusted with cartilage*, whose relations are equally intimate. In the neighborhood of joint ends there are, in the young, found areas of peculiar and unusual vascularity. These are the *epiphyses*, where cartilage is being transformed into bone in order to furnish the increase in length which characterizes all growing long bones. The increase in transverse dimensions occurs through the mechanism of the periosteum. The vascular supply is for the most part abundant, the intraosseous veins connecting always with the larger but deep venous trunks, usually in a quite direct manner. Hence it is that septic thrombosis occurring within the bone or beneath the periosteum leads so frequently to genuine pyæmic disturbances.

I have been in the habit of following Savory's teaching, and calling attention to certain anatomical and clinical resemblances between lung and bone, because, for the most part, the infectious and other diseases of the densest tissue of the body find their counterpart in those of the softest, and because, to the average student, the latter are so much more easily and commonly appreciated. In fact, the minute pathology of bone diseases has been until recently regarded as unnecessarily obscure, simply because of the difficulty of noting post-mortem appearances in the bones as easily and with as little disfigurement as in the lungs.

Bone and lung, then, react in a similar way to infections, the analogy being in some respects quite striking. Both are surrounded by firm investing membrane; both have more or less of spongy texture; both are extremely liable to tubercular or pyogenic invasion; while in either case the disease manifestations are usually found near the extremities (apices). Both are in close relation, the bones especially by their joint ends, with serous cavities which become secondarily involved in a majority of instances—in the one case as a pleuritic effusion or empyema, in the other case as a joint effusion or a pyarthrosis. In both structures may be seen beautiful pictures of miliary tuberculosis when present. Furthermore, the one is as subject to acute miliary invasion as is the other, while in both alike staphylococcus, streptococcus, pneumococcus, and other specific forms of infection are prone to occur. As in the lung one lobe or more may be involved, so in the shaft of a bone a single epiphyseal extremity or the shaft, or both together, may be the site of the disease. In both also local gangrene may result, its ravages being known in the one case as gangrene of the lung, in the other as *acute necrosis*.

Calcareous infiltration of bone is, then, to be regarded as simply an incident necessary to its physiological function, but not in the slightest respect preventing it from becoming inflamed or acting in any other way as do the soft tissues. Acute infection of any or all of the structures which go to make up a bone is possible; in fact, it is almost impossible to conceive of a serious infection which shall involve, for instance, the periosteum alone and spare the true bone beneath. Clinically, however, there are three locations in which infectious manifestations are most common: (*a*) Beneath the periosteum; (*b*) in the epiphyses; (*c*) in the diaphyses.

All bone marrow begins as red marrow, with 1 or 2 per cent. of fat, and ends by becoming yellow, with 60 or 70 per cent. of fat, and whether this change shall take place suddenly or rapidly depends upon diverse conditions. Many years ago it was claimed by Bourgery that bone is simply a large cavernous arrangement where stagnation of the blood-current favors the deposition of fat. Fatty alteration progresses from periphery to centre, and the bones of the hands and feet undergo fatty alterations before those of the trunk and pelvis. In other words, the truncal skeleton remains as "red bone" longer than the balance of the osseous system, and he whose sternum has become a really "yellow bone" must have reached a ripe old age. So in long bones distal extremities first become fatty. Individual peculiarities seem to govern these changes. Thus, the neck of the femur will sometimes be fatty and friable at the fortieth year, or reasonably firm and still red at the eightieth. This fatty condition is not to be confounded with true osteoporosis or rarefaction in bone, though it is often associated with it. When the two conditions are combined we have *osteoporosis adiposa.* Into this condition immobilized limbs pass more easily than those which are used. Their weeks have been equal to years of ordinary inactivity. Red bone seems to be too highly vascular to be a favorite site for tubercle, and distinctly yellow bone too non-vascular. Consequently, bone tuberculosis is less often seen at the very extremes of life. White bone, as those who make anatomical preparations call it, is most favorable for tubercular infection on account of its minimum contents both of blood and fat. These bones come most commonly from phthisical subjects.

Acute Osteomyelitis.

This condition was never accurately recognized until described by Chassaignac in 1853, and even he missed many of its distinctive features, although he gave to it a most descriptive name, "typhus of the limbs."

Pathology.—The disease is a distinctly infectious process, limited sometimes to the bone marrow and internal portion of the bone, sometimes apparently involving every particle of the osseous structure. Its onset is sudden, its manifestations most acute and serious, and its ravages, when not promptly checked, most extensive. The following more or less distinct varieties may be distinguished:

A. The Staphylococcus.
B. The Streptococcus.
C. The Pneumococcus.
D. The Tubercular.
E. Miscellaneous other Infections, including the Colon Bacillus, the Typhoid Bacillus, etc.

The staphylococcus variety is occasionally met with in its pure form. The streptococcus form is perhaps the more serious of the two, the tendency to general septic infection being perhaps even greater in this variety. The pneumococcus form has not been generally recognized until comparatively recently, and is no more necessarily connected with the development of a pneumonia than is any suppuration elsewhere due to this same organism. The onset and course of the disease are generally considered to be less acute than in osteomyelitis due to the organisms just above named. There seems also less tendency to subperiosteal

collections of pus and a greater tendency to more prompt repair. The pyarthroses accompanying the pneumococcus form are also less dangerous than in the staphylococcus form. The acute form of *tubercular osteomyelitis* will be considered under the head of *tuberculosis of bone.* Ever since the time of Boerhaave osseous complications and sequels of *typhoid fever* have been recognized, and since 1885 their pathogeny accurately described. Still more recently it has been discovered that the *colon bacillus* alone is also capable of setting up these acute suppurative lesions within the bones. The same is undoubtedly true also of the micro-organisms of certain other diseases, particularly of *influenza,* or *la grippe.*

Be the organism what it may, the mechanism of the infection and the lesions produced by it are essentially similar, and may all be described together. These consist of rapid *thrombosis, coagulation-necrosis,* and *suppuration,* along with the local destruction incident thereto, and with unlimited possibilities in the way of *auto-intoxication,* both from the local lesions and from the disturbance of the general economy and interference with excretion. Every severe case is accompanied by more or less of general septic intoxication, presumably from the ptomaïnes produced by the bacteria, while in many instances, particularly those where the bacteria at fault seem extremely virulent, the intoxication is overwhelming and the course a rapidly fatal one. Death has been known to follow within thirty-six hours after the first symptom of an acute osteomyelitis. For the average case three more or less distinct stages can usually be distinguished: first, a period of *purulent infiltration,* with the formation of local foci in the bone marrow and speedy secondary involvement of the periosteum and synovial membrane; second, a period of *sequestration or formation of a sequestrum* inside of an abscess-cavity; third, the *stage of repair.*

First Stage.—During this there occurs most violent inflammatory infiltration, localized areas becoming at first hyperæmic, then infiltrated with hemorrhagic exudate, whose rapidity of production will indicate the intensity of the infection, since often at the same time one finds enlargement of the spleen and hemorrhagic exudations in distant serous cavities, such as the pleura and pericardium. The locally infected areas of bone marrow quickly break down into dépôts of pus, which spread either toward the epiphyseal line or else along the Haversian canals toward the periosteum, which becomes both infiltrated and loosened. The loosening is particularly marked about the shafts rather than the joint ends, while, as a rule, that end of the bone toward which the nutrient artery is directed is the one whose epiphysis is first loosened. Nevertheless, about the knee it would seem as though the lower end of the femur and upper end of the tibia are the particularly predisposed localities.

In many instances obliteration of nutrient vessels and thrombosis are very early features of the case. The area of separation of the periosteum is usually an index of the extent of deep destruction. From the periosteum the infection may extend toward the covering soft parts, in which case we may have a parosteal abscess, or it may perforate toward the joint-cavity, leading quickly to pyarthrosis and destruction of joint structures. It would appear in children, particularly, that the epiphyseal cartilage forms often a barrier to the advancement of the lesion in the direction of the joint, and thus it happens that we have acute necrosis of the shaft of a long bone, with perforation through the periosteum at both of its ends. In adults this takes place less often, the joint ends being often primarily involved. Softening and separation of cartilages are usually secondary to the other processes. It is possible even to have the primary infec-

tion in the joint end proper, and extension therefrom to the epiphysis permitting of epiphyseal separation and extrusion of this fragment as a sequestrum. This separation occurs in many instances rapidly and before the attendant is alive to what has really happened.

Second Stage.—The second stage includes, coincidently with the occurrence of suppuration, the proliferation of considerable granulation-tissue, by which more or less protection is afforded; also, when time is afforded, the rapid formation of new bone, whose effect is to wall off the scene of conflict and death from the surrounding tissue, by which event prognosis, so far as the patient's life is concerned, is very much improved. Intraosseous abscesses may quickly coalesce, and the result may be one long tubular abscess extending through the shaft. At other times both bone marrow and the cancellous tissue are bathed in pus, while if the periosteum has been totally separated the consequence will be a sequestrum whose dimensions correspond with those of the shaft. When periosteum is not loosened the necrosis will probably be central and more or less circumscribed. (*Vide* Plate XVIII.)

The degree to which rigid osseous tissues are capable of yielding under these circumstances is astonishing, and we may have remarkable enlargements occurring within a comparatively short time, producing most striking discrepancies in size between healthy and diseased bones. The extent to which the periosteum has yielded may be in some respects estimated by the intensity of the pain, spontaneous subsidence of it being an evidence of spontaneous yielding of tissues and relief of tension. Epiphyseal separation is one expression of such yielding. Another is, for instance, the purulent diastasis of the tripartite suture entering into the formation of the acetabulum, while the external table of the skull or of the sternum may give way in the same manner.

Third Stage.—The third stage is the period of efforts at spontaneous repair. There is a natural effort toward elimination of the sequestrum by the process of softening or liquefaction in the direction of least resistance. This process may extend over months when surgical relief has been delayed, and may be accompanied by so much other disturbance as to completely ruin a bone or limb for further use. In neglected cases several sinuses may lead down toward the central sequestrum. On the other hand, once this sequestrum be eliminated an extraordinary amount of activity is usually displayed in the direction of repair.

Symptoms.—In a general way the signs and symptoms of all acute infectious lesions in bone are strikingly similar, and are most significant when construed aright. Patients complain usually first of *exhaustion*, followed quickly by *pain*, which may speedily become agonizing. This is often accompanied by an introductory *chill* with high fever, after which the general character of the disease quickly assumes the typhoid aspect. Evening temperature may rise high and be followed by some morning remission. The spleen is usually enlarged, the primæ viæ disturbed, and often we have to do with a fetid diarrhœa. In the young the sensorium is early affected and children quickly become delirious. The *pain*, at first vague, quickly focuses in the particular bone or bones most involved, and as it increases in intensity there is a more and more significant *tenderness*, which becomes exquisite. Ordinarily there is also early and characteristic reddening and swelling of the affected parts. With all these evidences goes also a characteristic muscle-spasm, by which certain posture signs will be produced varying with the bone involved.

PLATE XVIII.

Acute Osteomyelitis; Showing Purulent Foci and Accompanying Disturbances. (Kocher.)

Pain is always intensified by the slightest degree of disturbance. In consequence, the limbs (for it is the limbs which are usually involved) are contracted, and every effort to overcome the contractures is followed by aggravated pain. The more acute the pain the more vivid the external evidences of inflammation and the œdema of the parts, especially below and about the lesion. Thus it may happen that within forty-eight hours we have not merely swelling, but actual œdema of the part involved, which should be always regarded as pathognomonic.

A little later, superadded to the other signs of inflammation, we find *fluctuation* if parosteal abscesses have formed, or possibly the evidences of *epiphyseal loosening* or complete separation. When the disease is primary in an epiphysis the corresponding joint will be early involved, and the joint symptoms will take on rapidly the type of an acute purulent synovitis, only with a much more significant degree of pain. It is probable that under few, if any, circumstances is pain complained of more serious or aggravating than in cases of acute osteomyelitis of the fulminating type.

So far, only local symptoms have been described. To these there must be added the list of those pertaining to *thrombosis* and *metastatic infection*, with their septic and disastrous consequences. The disease is frequently so acute and rapid that even within the first day or two there is not only extensive thrombosis in and along the bones, with rapid purulent degeneration and thrombi, but that even more serious general condition to which these lesions so easily give rise—*i. e.* unmistakable *pyæmia.*

While patients may die of septic intoxication before sufficient time has elapsed to permit of the formation of secondary abscesses, yet it is known that death may result from true pyæmia within a comparatively very short time. Moreover, other septic infections—as, for instance, septic pneumonia, metastatic meningitis, pericarditis, nephritis, etc.—may occur in a more irregular or less classical manner. In fact, there are few, if any, infectious processes which can be followed by death from such a variety of causes, and which are so augmented by dangers if not promptly relieved, as acute infectious osteomyelitis.

The general symptoms are common to the disease, no matter what bone be involved. Local symptoms will, of course, change in accordance with their location. While not so common, the flat bones, like the pelvis, cranium, and sternum, may be involved in most active manifestations of this disease. The same is true even of the vertebræ, but, as a rule, it is in the long bones of the extremities that its ravages are most frequently seen.

In the case of the cranium, for instance, we have periosteal separation, extensive local swelling, and œdema, soon changing into fluctuation, while in the diploë the anatomical arrangements especially favor prompt pyæmic lesions. Among the less usual incidents are *subperiosteal hemorrhages* in the vicinity of epiphyses, with perhaps complete detachment of that membrane. Small, localized *subperiosteal collections of pus* may also appear at points quite distant from the internal foci. In the adjoining *muscles* there may be characteristic alterations, for the most part showing themselves as *white points* or *white lines* extending through the muscle-tissue. These are, for the most part, minute collections of pus or *linear abscesses.* These are seen more often in the tibialis anticus and in the biceps cruris than in the other muscles. Such spots may even be found in the heart-muscle in fatal cases. Disseminated foci are also found in various viscera. From almost all sinuses which have formed spontaneously the issuing discharge has a most offensive and fetid odor. Occasionally during the course of these cases peculiar *erup-*

tions are seen upon the skin, simulating scarlet fever or other exanthemata. These are due to the peculiar poisons generated by the pyogenic microbes, some of which are known to have a peculiar vasomotor excitant action. *Fat-embolism* is another of the complications of the fulminating forms of these bone infections. *Albuminuria* is not infrequent.

Of the different forms above mentioned, describing the disease in detail, it is not always possible to distinguish before cultures are made or before autopsy. As a rule, those which are due to the pneumococcus are distinguished rather by predominance of joint complications, with minor tendency to subperiosteal abscess or the sequestrum-formation, while clinically their course is more rapid, their symptoms more acute, and, when recovery follows, their duration relatively shorter. The pneumococcus form is not necessarily connected with manifestations in the lungs of pneumonia. When the disease is due to the bacillus pyocyaneus there is more liability to eruption on the skin and the odor from discharges is peculiarly fetid. In the most fulminant cases the staphylococcus seems to figure steadily, whereas in the post-febrile cases—*e. g.* those following typhoid or scarlatina—we are more likely to meet with streptococci alone or in relative abundance.

PROGNOSIS.—The prognosis depends in large measure upon the early recognition of the disease and the prompt affordance of surgical relief. There is perhaps no disease less amenable to purely medicinal treatment, and, if bones are to be saved in their entirety, early and free incision is called for. Consequently, when the case is seen late it almost invariably entails necrosis with more or less disturbance of function, or possibly such a serious condition as to call for amputation. The fulminant cases when not early recognized and promptly operated often prove fatal, and death has been known to follow within thirty-six hours after the onset of the first symptom, the fatal result being due to overwhelming septic infection with thrombosis, etc. Almost every case, however, if seen early enough, can be saved.

FIG. 264.

Atrophy of ulna and hypertrophy of radius, result of acute inflammation (Ollier).

COMPLICATIONS.—The complications are to be divided into the constitutional and the local. The former refer rather to the spread of septic infection and its more or less disastrous and remote ravages. Metastatic infections may produce serious or fatal complications, while, when less acute, important functions may suffer a serious impairment. Among the local sequelæ are to be considered mainly the results of destruction of bone-tissue and neighboring joint structures. When the

disease occurs in young and rapidly-growing children partial or complete arrest of development in the bone involved is not infrequent. This may lead to inequalities in length of the femora or humeri. It may lead also to compensatory hypertrophy of bone, with perhaps considerable distortion during subsequent growth (Fig. 264).

More or less persistent joint lesions frequently result, sometimes in the direction of *ankylosis*, partial or complete; sometimes as muscular *contractures*, which lead in course of time to *subluxations;* sometimes to persistent enlargements; sometimes to *torsion* and *flexion* of the bones themselves, largely due to muscle-pull. In another place[1] I have divided these deformities into those which pertain to juxta-articular lesions and those pertaining to the shafts of the long bones, to which those interested are referred for more particular description. *Dislocations* may be permitted by distention of the joint as the result of outpour of inflammatory products, or by early consolidation between epiphysis and shaft, with consequent cessation of growth along this line. A third form of dislocation is due to overgrowth of ligaments, permitted by constant hyperæmia of the parts and increase of nutriment, the ligaments, thus overgrown, stretching and giving rise to flail-like conditions. *Spontaneous epiphyseal separation* is of course equivalent to fracture.

An entirely distinct, much less serious, consequence of osteomyelitis is the condition usually known as *bone-abscess*, in which the acuteness of symptoms has long since subsided, but in which a distinct local focus remains. This will be considered by itself.

Etiology.—That the disease is an infection from the very beginning is settled beyond a doubt. The source of the infection, however, is not always easy to trace. Two distinct causes seem to conspire to produce the majority of these bone infections—*micro-organisms* of more than ordinary virulence, and a *predisposing condition* of the system, due sometimes to constitutional weakness or inherited taint or at other times to the results of exposure and fatigue. The causes of suppuration in general have been much more elaborately discussed in Chapter III., and it is hardly necessary to reiterate them here. It is a fact, however, that the majority of cases occur in children and after a combination of exposure and fatigue—as, for instance, sitting upon the ice after being exhausted in skating—all of which, however, would be inoperative to produce an infection were not the germs at hand ready to assail every tissue whose resistance is thus temporarily lowered.

The actual infection may occur *from within* or *from without*—from within perhaps through the alimentary canal or the respiratory tract, most probably in most instances from the tonsils and the pharynx. Infection from without may occur through a little abrasion or scratch, the blister upon the foot made by an ill-fitting shoe or by a skate-strap, or something of the kind. These cases occur almost always in the young, more often in boys than girls, probably because in the former more opportunities for infection are permitted. Bone infections, however, are possible even in the *new-born*, in which case the infection may occur through the pharynx or through the umbilicus, while the local resistance may have been lowered by the injury due to mechanical delivery, turning, etc. In elderly people the disease is almost unknown.

Diagnosis.—The disease for which this is most commonly mistaken is acute rheumatism. There may have been some excuse for this in time past, because of the lack of general knowledge of bone infections; now there is none. The majority of cases of necrosis following osteomyelitis which have come under my observation were the result of

[1] *Med. Record*, Nov. 2, 1895.

errors in diagnosis at the time when surgical relief might have prevented any local disaster.

Rheumatism is *never followed by suppuration*, nor does it produce, except in the rarest instances, a septic type of disease; its painful lesions are rarely so painful as those due to osteomyelitis, and the clinical picture is almost always easily distinguished. Lesions of rheumatism are usually multiple; those of bone infection, for the most part, single. The first complaint of pain in the latter is more likely to be along the shaft of a bone than at the joint end, while this is not true of rheumatism. Moreover, in acute osteomyelitis the disease assumes from the very outset a seriousness and gravity which is seldom if ever approximated by acute inflammatory rheumatism.

TREATMENT.—As stated, the treatment for acute osteomyelitis is essentially surgical. Anodynes may be necessary for relief of pain, but no time should be lost, when once the diagnosis is made, in making *incisions* sufficiently long and deep to expose the bone involved, and then, by means of suitable instruments, opening to its interior in order to relieve tension and to remove septic products. The incision required may possibly be ten or twelve inches in length, as over the femur or tibia. In almost every instance the tissues as we go deeper will be found more and more œdematous or infiltrated, with every evidence of the proximity of pus; the periosteum will be thickened and infected, and between it and the bone we may find collections of pus, as well as outside of it. If seen late, the characteristic muscle appearances already described may be noted. The periosteum should be incised completely down to the bone throughout the length of the incision, and then an ordinary bone-drill may be used to perforate the bone for exploratory purposes, just as the aspirating needle is used in the soft tissues. From every puncture in the bone thus involved will exude purulent fluid, often sanious, thus indicating the condition within. It is now necessary, with the bone-chisel or other suitable instruments—made for the special purpose—if at hand, to cut a deep groove or channel, perhaps from one bone end to the other, completely opening into the marrow-cavity, in which numerous foci will be discovered or in which all distinctive structure of bone marrow may be lost, the cavity being filled with pus. The entire pus-containing cavity, being thus freely opened, should be scraped and disinfected with hydrogen peroxide and cauterized with zinc chloride or its equivalent, and packed, the wound being left open. Even this may not always be enough, but if there be epiphyseal separation, or, more unfortunate yet, if there appear evidences of joint infection, the neighboring joints must be explored, first under aseptic precautions, while if pus be found within, they must then be freely opened, washed out, and drained. Meanwhile, if in the soft tissues exposed by the incision the parosteal veins be found filled with septic thrombi, they should be opened so far as exposed and their contents removed.

These operations are often severe, perhaps prolonged, but nothing in the way of operative treatment can be so severe nor so serious as the disease itself when left unoperated; and the rule then is stringent and far-reaching that every infected tissue, and especially every infected bone interior, must be thus exposed without mercy and thoroughly cleaned out. Only in this way can lives be saved which would otherwise be certainly lost. Moreover, it is necessary to carry out this treatment in the fulminant cases *as early as possible;* and, consequently,

errors in diagnosis by which it may be postponed until metastatic infection or grave pulmonary and cardiac complications have set in are most unfortunate. So long, then, as the local indications are as above described surgical treatment is loudly called for, whether the systemic complications be pronounced or not. The immediate effect of the operation having passed away, the relief thus afforded will often prove amazing—to such an extent that within twenty-four hours patients may be comfortable and evidently out of danger who were at the time of operation in the gravest danger of a speedy fatal termination.

The later results of this operation are a wound which will discharge at first freely, and which, so soon as septic material is out of the way, will begin to *granulate*. Ordinarily, no attempt should be made to close such a wound, though much may be done to favor rapidity of granulation. While some antiseptic dressing is always employed, it will be of advantage occasionally to change the character of the same, and to alternate between perhaps iodoform with boric acid and acetanilid, the effect of any one drug being apparently lost after it has been used for some time.

There are some cases where an entire diaphysis or bone-shaft will be found separated from one or both epiphyseal terminations, lying in a subperiosteal abscess-cavity, bathed in pus, and dead beyond possibility of repair. This is *total necrosis of the shaft* from an acute infectious process, and is to be treated by complete removal of all dead and dying tissue. In the case of the forearm or leg it may be that the remaining bone, when only one is involved, as is usual, will be sufficient to maintain the integrity of the limb until new bone can be reproduced within the periosteal bed occupied by the old one. More or less complete *regeneration of bone* is possible, particularly in the young, and in connection with compensatory hypertrophy of the parallel bone will permit the restoration of the leg to partial or complete usefulness. On the other hand, should this prove later a complete failure, amputation and substitution of an artificial limb may be called for.

When the disease has involved the articular side of an epiphyseal line, and when we have complete epiphyseal separation with consequent *pyarthrosis*, the probable consequence will be necessity for a complete or partial resection of the joint and the probability of subsequent ankylosis. Patients may find later that a modern artificial limb with its possibilities will be much preferable to such a condition, and may readily consent later to an amputation which they would at first refuse.

Acute Infectious Periostitis.—This is an infection of the same general character and type as the osteomyelitis just described, but refers to those cases where the disease apparently is confined to the periosteum and the outermost layer of the bone. In its possibilities for harm it is scarcely less serious, although in its tendency to spontaneous perforation and escape of pus it is less likely to prove fatal.

The CAUSES and the general clinical manifestations are practically identical. The disease is perhaps a little less grave in its acute manifestations, the localization of pain more exact, with ordinarily less tendency to serious joint complications. Local tenderness is exquisite, and particularly in those bones which lie near the surface—*e. g.* the tibia—and early recognition of fluctuating areas is easy. It may be localized over a small area or the entire periosteum of the shaft may be involved; in which case, so soon as pus forms and the periosteum is separated from the bone, there is probability of acute necrosis of the shaft. Here,

again, there may be a tendency to mistake at least the first signs of the disease for acute rheumatism, from which it must necessarily be early differentiated as above.

TREATMENT.—Here also there is the same necessity for immediate intervention, if possible before pus has formed, in order that there may be little or no periosteal separation and encouragement to necrosis. Anæsthesia is necessary, with prompt incision, the use of the sharp spoon, and disinfecting agents: no attempt should be made to close the wound, but drainage should be favored in every way. The intensity of the pain is promptly relieved and the whole clinical picture immediately changed by such a procedure.

The ordinary *bone-felon* upon a terminal phalanx is practically an expression of this type of disease, and universal experience corroborates the wisdom of deep and early incision, even in the case of so small a bone-entity as a phalanx.

Acute Epiphysitis.—This is a term applied rather indiscriminately to a form of acute osteomyelitis involving primarily and especially the the epiphyseal lines, or to a condition of hyperæmia and neuro-vascular excitement at epiphyseal junctions, stopping short of suppuration, but giving rise to intense pain, muscle contraction, joint tenderness, etc. It is most often seen at the upper end of the tibia. Sympathetic disturbance may extend even to serous effusion into a joint, although this is not necessarily the case. The limbs are early drawn up, and every attempt to extend them simply aggravates the distress. So long as there be no evidences of suppuration, it is sufficient in these cases to apply a sufficient degree of traction to overcome muscular contracture and to completely straighten the limbs. This must probably be applied first under anæsthesia, and the patient be kept under anodynes for a few hours thereafter. So soon, however, as the muscles are tired out by the steady traction, pain subsides, and the intensity of the condition may be thus relieved within forty-eight hours or less. It would be well to continue physiological rest and traction so long as there remains the slightest tenderness. Should evidences of suppuration supervene at any time, incision and evacuation of pus and exudate must be practised.

Periostitis Albuminosa.—This is a quite rare manifestation of bone disease, only given an identity of its own since 1868, when Ollier first distinguished it, and since which time it has been the subject of considerable controversy. The name refers to a condition less acute than the infectious periostitis just described, localized for the most part in a single bone, calling almost always for incision and evacuation of a fluid which is *gelatinous* or *mucoid* in appearance rather than purulent. It is because of the peculiarity of the subperiosteal collection of fluid that it has in time past received the name *periostitis albuminosa*, and it was not generally regarded until recently as a variety of the infectious form of periostitis. It is, however, now generally conceded as being a mitigated form of infection in which the products of exudation assume the serous rather than the purulent type. In certain instances it appears to be the tubercle bacilli which are at fault. At all events, the organisms which produce the disease are more or less virulent, else the clinical form of the disease would be less serious than it really is. Cultures made from these subperiosteal collections have in almost all recent instances

revealed the presence of some one of the numerous pyogenic organisms. Within the past year Dor has described a polymorphic microbe in instances of this kind which he has called the *bacillus cereus citreus*, with which he claims to have been able to reproduce the disease in animals.

Chronic and Latent Osteomyelitis.—So far, I have described only the most acute manifestations of bone infection. As in the lungs, however, very chronic lesions are met with, and as in the lungs, again, it is possible for collections of micro-organisms to become more or less encapsulated and for a long time to lie *latent* until some provoking cause excites them again into activity. In this way are to be explained the numerous instances of recurring abscesses within the bone necessitating repeated operations, often at long intervals (Plate XVIII.).

Fig. 265.

Compensatory hypertrophy of fibula, following fracture.

The explanation is first an acute infection, which has been incompletely, if at all, attacked, and in which dépôts of pyogenic bacteria have been walled in by granulation-tissue which may later have ossified. Here there lurk quiet or latent possibilities for harm for months or years, a period of at least twenty years having been positively established in numerous instances. The occasion which may call out their destructive capabilities may be either *local injury*, as fracture, bruising, or a local ischæmia from any cause, or, on the other hand, a *lowering of vitality*, such as may be produced by the puerperal condition, by the acute exanthemata, or by any of the acute infectious or wasting diseases. Starvation, over-exertion, or exposure may have the same effect. The consequence is a recrudescence of local symptoms and the return of all the previous evidences of deep suppuration, though probably in mitigated degree. This is one of the common causes of bone-abscess, and calls, practically invariably, for operation in the shape of exposure of the area involved, removal of the overlying bone, and complete cleaning out of the deeper focus or foci. In many instances this repetition of disease occurs several times, and patients are often subjected to numerous operations because of failure to make the first or an early one complete. In cases of this kind nothing, however, can be done save to operate whenever local pain, tenderness, and swelling, with perhaps constitutional symptoms, make it necessary, and then with all possible thoroughness.

Possible Consequences of Any or All of the Bone Infections.—Keeping ever in mind the fact that bone is a living tissue, calcified and stiffened by inorganic material simply for the purpose of giving it strength, we must not forget that as such it may suffer remotely from the consequences of local infections, as may any other tissue. Thus, it may have its nutrition impaired so as to produce *atrophy* on the one hand, or increased so as to lead on the other to *hypertrophy*, either regular or irregular in outline. Again, in its texture it may be altered to a very wide extent between the degree of extreme sponginess or porosity on one side (*osteoporosis*), or to the greatest degree of density ever attained by ivory

(*osteosclerosis*) on the other. Similar changes are also noted in cases of bone tuberculosis, which is to be considered by itself. The *densest* bone has sufficient vitality to permit its nutrition and life, and may assume dimensions much larger than that of the original, and a hardness which will defy the best steel instruments should it become necessary to operate upon it. The other extreme of *osteoporosis* includes a condition where the bone has barely sufficient inorganic material to permit it to retain its shape and ordinary proportions. Such bone is fragile in the extreme, and scarcely serviceable as a supporting tissue. The principal portion of its bulk is constituted by marrow-tissue, which make it extremely vascular, but far from strong. When spongy to this degree, it is ordinarily unserviceable for its proper function. Astonishing pictures of *osteosclerosis and osteoporosis side by side* are present in many instances of disease, the latter being often evidence of more or less ossification of new-formed granulation-tissue. This is often a happy combination, because the bone, which for the most part has been sadly weakened by disappearance of its calcareous material by liquefaction and by absorption, is reinforced along some of its lines by a pillar of osteosclerotic tissue, by means of which it still functionates as a more or less useful support. (*Vide* Fig. 266.)

Fig. 266.

Osteogenesis and osteosclerosis in slow infective processes (original).

The operating surgeon has to familiarize himself with the density of normal bone in various locations, since in many operations upon the deeper bones he detects healthy bone rather by the sense of *touch* and of *hearing*, and the *resistance* which it offers to his instruments, than by sense of sight.

Tuberculosis of Bone.

In Chapter IX., on Tuberculosis in general, the writer went into considerable detail with regard to the nature of tubercular lesions, which were stated to be essentially the same whether occurring in hard or soft tissue, the active agent being the now well-known *bacillus tuberculosis*, which, finding lodgement, for instance, in the osseous tissue, acts as a specific irritant, and so provokes the production, first, of a typical tubercle, and, later, of typical granulation-tissue, by whose ravages the distinctive signs of bone tuberculosis are produced. This process, then, is in no respect different in bones from similar lesions in other parts, though modified to a slight extent pathologically, to a greater extent clinically, by the dense environment. Nevertheless, trifling or most extensive destruction of bone substance is produced by this tissue, while

by continuity or by metastasis there is more or less involvement of the adjoining textures, either parosteal or articular. It is by granulation-tissue that so-called *caries* is produced, and it is by the same tissue that distinct portions of bone are sometimes completely segregated from their vascular surroundings and shut off from nutrition, so that they die and form what are known as *sequestra*. *Necrosis* may, then, be the result of tubercular disease.

So long as the process be active, this granulation-tissue tends ever to enlarge its boundaries, and, like pus, to spread in the direction of least resistance. When produced in the shaft of a long bone this may lead to involvement of the entire shaft, or there may be liquefaction and absorption of dense bone and the formation of a sinus from the marrow-cavity to the periosteum, beneath which the granulation-tissue will spread, and through which it will sooner or later perforate, to resume its progress toward the surface, *always in the direction of least resistance*. In this progress *tendon-sheaths* or *bursæ* may be involved, or dense aponeuroses may turn the granulation column aside, causing it to perforate toward the surface at some remote point; while, in the end, it may spread out more or less beneath the skin before finally causing its destruction. Sooner or later, if uninterrupted by treatment, this escape will occur, and then we have the condition of a tubercular ulcer of the skin, from which leads down, by a devious path, a *sinus* toward the original focus.

When this original focus has been juxta-epiphyseal, we see speedy involvement of the epiphyseal cartilage and a pathological *diastasis* which may early lead to spontaneous or pathological *luxation*. Or, again, a focus, having once originated at an epiphyseal extremity, tends usually to perforate quickly into a joint-cavity, after which a considerable length of time is usually expended in filling up this joint-cavity with exuberant granulation-tissue. This is the material so often found in tubercular joints, and is well characterized by the name given to it by the Germans, *fungous tissue*, they calling such joint affections *fungous joint inflammations*.

Seen thus in joints, after it has been long exposed to friction and to more or less pressure, it may have lost some of its original luxuriant features. It is best seen when it is freshest and has been exposed to least disturbance. Under these circumstances it is vascular, dark red in appearance, friable, and easily removed from the tissue upon which it has grown. Ordinarily it is infectious, and by its inoculation into animals is capable of reproducing the disease.

The PATHOLOGY of tuberculosis of bone may, then, be virtually summed up in saying that it consists of the ravages produced by the presence of this granulation-tissue, with the irritative hyperplasia of surrounding tissues which its presence always excites, even though they be not actively infected. This is, then, the explanation for the majority of cases of *caries*, of *tumor albus*, of *Pott's disease*, of *spina ventosa*, and of the condition which at various times has been known under many other names.

So long as this tissue be protected from access of air or from external infection, it usually does not suppurate, but when once *infected*, usually from outside sources, it *breaks down very rapidly*, and then we have the condition already described in Chapter IX. as *cold abscess* or its equivalent. Under certain circumstances it also *caseates*, and we frequently find it in old tubercular lesions, having undergone more or

less of this remarkable charge. It may involve and perforate small or large veins, in which case *metastatic tubercular disease* is easily produced. There is no bone in the body exempt from its ravages, and even the firm tissue of the petrous bone will break down in its presence. The *psoas abscess* of Pott's disease is to be explained as first a tubercular caries of the vertebræ, with subsequent infection, probably now from internal, at least from indirect, causes, and then profuse suppuration, the pus taking its course in accordance with the universal law, travelling in the direction of least resistance. When high in the vertebral column, it may appear in the pharynx, causing retropharyngeal abscess; from the dorsal spine it may produce psoas abscess; while from the lumbar spine it travels nearly always posteriorly, to appear as a lumbar abscess. Tuberculosis of the flat bones—*e. g.* cranium, sternum, and pelvis—is not at all uncommon, and extensive destruction with either internal or external perforation may occur (Plate XIX.). While the disease may possibly be primary in the periosteum, it occurs almost first in the bone-tissue proper. In the young it always manifests a preference for joint ends of the long bones; in the middle-aged or adult it affects, for the most part, the diaphyses of the long bones or else the short, like those of the carpus and tarsus, but by continuity of tissue it may spread from one to another until finally several bones are involved in the diseased area. This is the affection formerly known as scrofulous disease of bones—a term which ought to be expunged absolutely from surgical literature. This, too, is the real explanation for most of the cases of hip-joint disease, white swelling of the knee, Pott's disease of the spine, etc., those which are not to be explained in this way being due to primary tuberculosis of the synovial membrane rather than of the bone. Occurring in or about the joint, however, it is not possible for any of the joint structures to escape, provided it remain long active.

Varieties.—Acute Miliary Tuberculosis of Bone.—This corresponds to a similar invasion, for instance, of the lungs. It might be fittingly described as an *acute tubercular form of osteomyelitis*. It may run its destructive course within a short time, and cause such involvement of structures as to necessitate amputation of a limb, or it may appear in the truncal skeleton as a primary disease, spreading rapidly therefrom and involving the viscera or the cerebro-spinal membranes, and causing an early death, perhaps within a few weeks after its onset. This condition has been in time past more prevalent than generally understood, and has not even yet received the attention it deserves. It is perhaps less painful than the pyogenic forms of osteomyelitis, and may assume less of the septic, and more of the typhoid or meningeal, type of disease. The pain also may be less severe, though reflex symptoms, especially muscle-spasm, will be an early and marked feature of these cases. Involving a limb, the case may not be hopeless, but when involving the cranium, spine, or trunk it is fatal, and little, if anything, can be accomplished by treatment. The operative treatment for parts which are inaccessible is virtually that already given under Acute Osteomyelitis, to which the reader is referred.

Chronic Tubercular Osteomyelitis.—This is the ordinary form of the disease, and is exceedingly common. In certain parts of the world it constitutes nearly one-third of the diseases calling for surgical treatment in clinics and hospitals. This is particularly so in the most thickly-settled portions of the European continent. In Buffalo it constitutes from 15 to 20 per cent. of cases found in my wards and in my clinic. In fact, the proportion during certain years has been larger.

The pathological picture of the phthisical process in the lung is not a bad illustration of the same disease in bone. We find here the same irregular distribution of caseous or suppurating foci or of fresher granulation-tissue, interspersed with cancellous tissue which has so far escaped its ravages; and we find the same

PLATE XIX.

Tubercular Disease of Hip Joint and Pelvis, involving the muscles (rare); *o*, Rarefying Ostitis, *i. e.*, Osteoporosis; *f*, Fungous Granulation Tissue. (Lannelongue.)

tendency to *fibroid* or sclerotic changes, a bone so involved presenting, in the neighborhood of the tubercular focus, a composite picture of osteosclerosis and osteoporosis in close relation, the margin of a bone-sinus perhaps being almost eburnated, while within a very short distance of it the bone-tissue will be so disintegrated as to yield to the finger-nail. Along with this we find *thickening of the periosteum*, sometimes to a relatively enormous extent, and serous or purulent *outpour in joints* corresponding closely to the pleuritic and empyemic complications of phthisis. As the result of the obstruction to the deep circulation there is *enlargement of the more superficial veins*, corresponding to that often seen about the chest of consumptives, while *œdema* of parts below the diseased area is not infrequently noted. The overlying skin has usually a characteristic anæmic and waxy appearance, displaying to greater advantage the dilated veins beneath. Owing to the infiltration of parts in the neighborhood, especially when joint ends are involved, there is a constantly increasing degree of *fixation*, while, should granulation-tissue be approaching the skin, the fact can be recognized by the livid and distended appearance of the parts at the point where it is threatening to perforate. Sometimes it may even be seen as a purplish mass just beneath the skin. Evident *fluctuation* in joint-cavities will always indicate the presence of pyoid material (see p. 165), while it seldom happens that the fluid contained within distended joints is pure serum nor anything thinner than sero-pus. *Erosion of cartilages* or complete destruction and obliteration of all joint-structures is seen in advanced and destructive cases; or, when pyogenic infection has been avoided, the reverse obtains, and there is such sclerosis of all the adjoining structures as to completely immobilize joints in a condition often spoken of as *fibrous ankylosis*.

Fig. 267.

Tuberculous disease of hip (original).

Symptoms.—*The essential symptoms of bone tuberculosis* are *muscle-atrophy*, *muscle-spasm*, and *pain*, direct or referred, and upon the existence of these, coupled perhaps with *local tenderness* and *local swelling, a diagnosis can almost always be made.* *Muscle-atrophy* is distinct, and is not alone that of disuse, but is even a distinctive evidence of the tubercular process. It involves the parts above and below the lesion.

Muscle-spasm is never lacking, but is most noticeable about the spine and the joints of the extremities. In Pott's disease, for instance, the condition causes a stiffening of the back and an inflexibility of the spine which are always recognized as distinctive. About the joints it leads gradually to *fixation*, usually in the condition of more or less flexion, the flexor muscles being ordinarily stronger than the extensors in all parts of the body. Thus we see the knee and the elbow drawn up, and most other joints in a condition of flexion so far as it may be permitted.

It is characteristic also that *muscle-spasm* is frequently exaggerated, usually in a reflex way, by which pain is always augmented. These sudden but brief contractures occur more often during sleep than during

the waking hours, and give rise to the so-called *starting pains*, usually nocturnal, which are noted in nearly every case of this kind.

The *pain* is in large measure the result of contracted muscles pulling tender joint surfaces together, and is consequently augmented during the muscle-spasms just described to an extent causing the patient to cry out even during sleep. There is also usually a more or less deep-seated and constant pain or soreness, manifested in increasing degree as the lesion advances. These pains are also often *referred*, it being quite generally the case that lesions in the upper ends of long bones give rise to pain which patients refer to the lower ends. Thus, in hip-joint disease pain is often referred to the knee; in Pott's disease, often to the anterior part of the trunk. Of all cases it may be said, in a general way, that slight but slowly increasing disturbance of function of a joint inaugurated by trifling muscle-spasm, with complaint of aching or pain, is most significant, and should call for careful examination, it being a mistake to anæsthetize patients for this purpose, since by the anæsthetic the pathognomonic muscle-spasm is abolished and mistakes in diagnosis favored.

Fig. 268.

Healed tuberculosis of spine (original).

Treatment.—The treatment of tuberculosis of bone is both constitutional and local. The former consists in the best possible hygiene and in those measures which are everywhere recognized as helpful in similar conditions. I believe in the internal use of *benzosol*, or its equivalents, in doses large enough to quickly impress the tissues with its influence. I believe also that the treatment by tuberculin, or its equivalent preparations, is helpful, although by no means self-sufficient. In addition to these, the very best tonics and evacuants should be judiciously used. But it is mainly with local treatment that we shall here have to deal.

The *local treatment* may be divided into the *non-operative* and the *operative*. The former consists in enforcing the general principles of physiological rest, which is done partly by *orthopædic apparatus* proper and partly by the general principles of *traction*, and is resorted to mainly in a class of cases treated of in Vol. II. under Orthopædic Surgery, the best methods for the purpose, apparatus, etc., being found under that heading.

In a general way, by traction proper is meant sufficient pull upon a limb to overcome and to undo the most serious effects of muscle-contraction. The pain

complained of in and about tubercular joints is, for the most part, due to joint tenderness and the extra pressure made upon joint surfaces by muscles in a condition of chronic spasm. By traction we have no expectation of completely separating these surfaces, but do in most cases, especially when thus treated, easily overcome chronic and excessive muscle-pull, and so relieve pain.

Aside from this, a hopeful method has been that recently suggested by Bier, consisting of making an *artificial chronic congestion*, it having been long known that tubercles do not thrive when bathed in too much blood. The congestion is secured by wearing an elastic bandage above the point involved, elastic constriction being made to a degree as great as may be comfortably borne. The result is venous congestion, possibly œdema of the parts below, which to be made effective should be carried nearly to the tolerable extreme. Constriction, when applied for this purpose, may be at first enforced for only a short time, but can be later borne for longer and longer periods, until a time is reached when the patient can wear a comfortably snug bandage nearly all of the time. Marked improvement follows this method in many cases.

The operative treatment consists in *ignipuncture, curettage, or formal extirpation. Ignipuncture* is the insertion into the bone-focus, no matter how deep, of the glowing point of the thermo-cautery. It is best practised under an anæsthetic, and when the bone is superficial no hesitation need be felt in plunging the cautery directly through the skin, making it burn its way into the depth of the bone. This is easy when the cancellous tissue is that at fault. If the bone be deep, an incision may be made down to it, after which the cautery is applied as above. The result in almost every instance is relief from pain, frequently surprising in its rapidity and effectiveness.

This effect seems to be brought about partly by relief of tension, partly by destruction of diseased tissue; again, in large measure, by the acute congestion which is the result of the most vigorous counter-irritation. It need occasion no fear nor difficulty, and is applicable to all accessible bones. It must not be expected to cure every case, but is a measure which may be confidently expected to relieve pain and to do good.

The more *radical* form of *treatment* is always called for when one can determine in any way that the carious process is advancing or that pus or caseated deposits are present. This is made known in various ways already indicated; but when one is reasonably sure of their presence it is best to begin the operation as an *exploration*, going so far as the findings may justify. This may include merely scraping out of a small focus, or it may entail removal of a large portion of a bone or resection of a joint, or even amputation, according to the severity of the deep lesion. It is best to do whatever may be necessary, and to do it all at once. The operator should not rest content with mere operative attack, but should carefully *disinfect* the entire tract, cutting away or removing with the spoon all the sinus-wall and all fungous tissue, which he should follow wherever it may lead, disinfecting freely with hydrogen peroxide or caustic pyrozone, and then using some active caustic, like zinc chloride or the actual cautery, unless he have already used caustic pyrozone. In this way material may be destroyed which has escaped the instruments used; and in this way, also, absorbents are seared or closed and protection afforded. My personal preference is for a packing made of iodoform gauze, soaked in a mixture of balsam of

Peru containing 10 per cent. of *guaiacol*, which I find more advantageous than anything I have used. One should always add to these measures, however, whatever may be necessary in the way of after-treatment, both local and constitutional, and should be prepared to operate again should latent foci subsequently manifest themselves or should there be recrudescence of the active disease.

Bone-abscess.

Bone-abscess is a term applied to *deep and circumscribed collections of pus within the bone*, for the most part within the shafts of long bones. They are due either to the acute ravages of pyogenic cocci or to the slower lesions produced by the tubercle bacillus. They are frequently evidences of return of disease of the acute type after a more or less long period of latency. The manifestations are usually quite localized, in this respect differing materially from those of acute osteomyelitis. The pain is deep-seated and boring, while there is local tenderness, often with considerable enlargement of the overlying bone. The lesion occurs more often in the tibia than in all of the other bones put together—at least under those clinical conditions which entitle it to be called bone-abscess. The pain is frequently *nocturnal* or osteoscopic, and patients may endure it for weeks or even months before coming for operation or relief.

One may always expect to find a layer of condensed, sometimes extremely hard, bone around these local foci, and it is due to this that they do not either perforate or diffuse and cause extensive trouble.

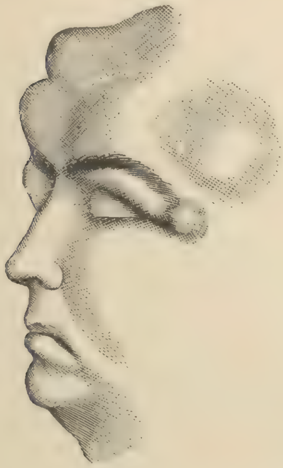
Treatment.—Treatment is always *operative;* should consist in anæsthesia, exposure of the bone, effective exploration by means of the bone-drill, as one would use the hypodermic needle for exploration in the soft parts, and then the free use of the bone-chisel or other instruments by which the area may be widely exposed. The density and firmness of the bone under these conditions will sometimes almost defy the best-tempered instruments. Care should be taken to make the external opening as large, or nearly so, as the deep focus, in order that the surface may not heal too readily and before the deeper part is filled up. The same directions with regard to cauterization and packing the cavity obtain as given before.

Syphilis of Bone.

Syphilis of bone may assume the type of *gummatous involvement* of the *periosteum* or of the *bone* itself or of *syphilitic caries* and *necrosis.* The former appears usually as a distinct tumor, ordinarily tender and exceedingly painful, especially at night, it being characteristic of almost all cases of bone-syphilis that the pain, however great during the day, is exaggerated at night. The true syphilitic *gumma*, or syphiloma, of *bone* is but little, if at all, different from gumma in other tissues, which may become secondarily infected and then suppurate with the formation of sinuses, etc. Suppuration, however, is rare. *Central gumma*, like central osteosarcoma, is possible, and will probably lead to expansion of the surrounding bone. Syphilitic *necrosis*, so far as the bone lesion is concerned, scarcely differs from the other varieties already described or

to be described. It is, however, almost always of the slow form, and involves more often the *flat* than the long bones. It is especially seen in the cranium and the sternum. Syphilis of bone is often mistaken for rheumatism or pseudo-rheumatism, because of the deep-seated, somewhat indolent, pain. Syphilitic disease of bone permits occasional spontaneous fracture, the bone affected with this disease being always more friable than natural. There is also another form of bone-syphilis—namely, the *hereditary*—which deserves a moment's consideration. It leads, usually early, either to bone *enlargement* or to *caries* and necrosis, the latter most usually upon the cranium, where extensive ulceration and sequestrum-formation may be observed, even the dura being exposed by breaking down of fungous tissue.

Fig. 269.



Syphilitic gummata of head and face (after Jullien).

Fig. 270.

Syphilitic ostitis and osteosclerosis (original).

Hereditary bone-syphilis is also characterized by osteophytic formation, by the substitution of gelatinous for spongy bone-tissue in the neighborhood of epiphyses, and by early and easy epiphyseal separations. It is characterized also by irregularity of ossification of cartilage and consequent deformity of bone ends, especially about the phalanges and the metacarpal and metatarsal bones. In almost every case where doubt would in other respects arise, the other evidences of congenital or acquired syphilis are so plain as scarcely to permit uncertainty. (*Vide* Fig. 270.)

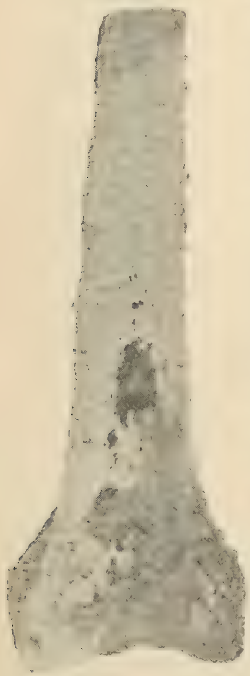
The possible *combination of syphilis and tuberculosis* in the same subject must never be forgotten, the lesions partaking of one or the other character according as the tubercular or syphilitic taint may predominate.

There is urgent necessity in all cases of syphilis in bone, whether operated on or not, for the *combination of suitable internal treatment with surgical interference.* Only by this combination can the efforts of the surgeon be crowned with ultimate success. In failure to appreciate this fact operation often seems to be almost futile.

CARIES.

Caries is a term applied to infiltration of and substitution in healthy bone by granulation-tissue, and has been in use for many centuries, from a time long before the pathology of the condition was understood. Caries never occurs except in the presence of a *specific irritant*, which for the most part is tubercular, sometimes syphilitic, in character. The pure type of caries is connected entirely with the formation of granulation-tissue, already repeatedly described, and the slow ravages connected with its presence in and substitution for the original bone. So long as *septic infection* (pyogenic) *be avoided*, it assumes the *dry* type, as it used to be known, called by the older writers *caries sicca*. When the fungous tissue is invaded by putrefactive or pyogenic organisms suppuration of course occurs, and then we have the *moist* forms of caries, the *caries humida* of our forefathers, connected always with the presence of pus. When closed areas of bone, small or large, being thus shut off from nourishment, die as the result of its presence, the complicated condition used to be known as *caries necrotica*. Occurring under any circumstances, *caries is a result and not a cause*, and is to be dealt with accordingly.

FIG. 271.



Caries of lower end of femur.

Peculiar alterations and markings in bone are the consequence of carious changes, and bones are given a most fantastic and peculiar appearance in consequence. The surface is almost always irregular, tunnels or canals are formed, and the bone is often honeycombed, as it were, by the excavations just made. Along with the process of osteoporosis and disappearance of bone at one point may be seen osteosclerosis in the adjoining area, and the bone, which is apparently much weakened by the destructive process, is strengthened in a compensatory way by the artificial density of the tissue undestroyed.

Caries, being but an expression of tubercular or syphilitic, possibly of other specific disease, has been thus sufficiently if briefly dealt with both from the pathological and the surgical standpoint. Its clinical evidences are those of joint and bone tuberculosis or syphilis, which have been already discussed, and its operative treatment consists always in surgical attack with bone-chisel and sharp spoon, according to the rules already laid down. The bone which is completely carious calls for *extirpation*—*i. e.* usually amputation. In the carpus and tarsus *resection* will often suffice, as also when the disease is limited to joint ends. Occurring in the pelvis, ribs, sternum, or cranium, more or less extensive *resections of flat bones* are called for, in the latter place leading often to exposure of the dura (of which one need have no fear) when necessary. The same rules with regard to cleansing and packing the wound are to be carried out as given before for operation on tubercular bones.

Necrosis.

Necrosis corresponds to gangrene of soft parts, and the term, when used by itself, is by common consent limited to death of bone-tissue. Necrosis by itself is never a distinct disease, but simply indicates the termination of some preceding disease process. It may be considered as—

(*a*) Traumatic.

(*b*) Pathological—*i. e.* the result of disease; or

(*c*) Toxic, due to the presence of specific poisons in the system.

(*a*) **Traumatic necrosis** is, for the most part, due to the shutting off of blood-supply by accident or by separation of the whole or a part of a bone in the same way. Thus in consequence of *multiple fractures* fragments occasionally die and require later removal. The same result has been ascribed to traumatic or *non-traumatic embolism* of the principal nutrient artery of a bone, but the possibility of this pure condition is very doubtful, bone being too well supplied by its surrounding periosteum. Necrosis in connection with fracture is rare except in compound fractures, and, when a detached fragment can be seen, may and should be anticipated by removal of the same.

(*b*) The **pathological form** is due almost entirely to the pre-existence either of *tuberculosis*, *syphilis*, or an *acute infection*, such as *osteomyelitis* in some of its expressions. It may also be the result of *acute infectious periostitis*, where the periosteum is completely loosened from the shaft of a long bone. These conditions have been already described at some length, and it would scarcely seem necessary to do more than allude to them as causes. They are connected either with the slow ravages produced by granulation-tissue, so often alluded to, itself being the result of the provocation of a specific irritant, or else to the acute septic processes by which infected exudates shut off large areas from sufficient blood-supply, or by which in consequence of septic thrombosis a similar result is brought about. In consequence, we may have bone dying in small visible particles, or the entire shaft of a long bone or several smaller ones may be at once involved in the destructive processes.

The portion which dies, be it larger or smaller, is known as the **sequestrum**, which may assume most irregular and unusual shapes, varying entirely with the area involved. The general character and size of a sequestrum will depend, for the most part, upon the nature of the cause. In acute osteomyelitis it is usually either an entire bone-shaft or an entire epiphysis which thus suddenly dies. In the slower processes, connected really with caries, the fragments may be of almost any imaginable size and form—irregular with jagged ends, or long, extending completely through a bone, either from end to end or from side to side.

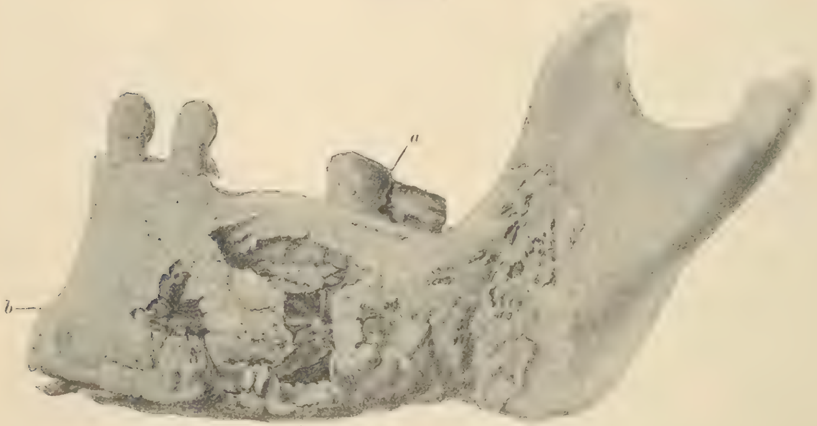
(*c*) The **toxic forms of necrosis** are due mainly to two substances used in the arts—*mercury* and *phosphorus*—whose use seems to be inseparable from the manufacture of many modern industrial products.

Mercurial necrosis may come either from the volatilization of the metal in factories where mirrors are made or from refineries where amalgam is distilled. It may also come from the *internal use* of the drug. Its effects are seen rather in the alveolar portion of the lower and upper jaw than anywhere else. It is, in fact, through some unknown peculiarity that the jaws are the bones commonly involved in both of these forms.

Phosphorus-necrosis, on the other hand, manifests itself almost entirely in the lower jaw, and is met with, usually among the young, in factories where matches are made. It is due to the vapors of phosphorus, which cause a form of nearly distinct maxillary necrosis—a fact which has been so widely recognized as to lead to state legislation preventing the employment of the young in such work.

Phosphorus-necrosis *begins as a periostitis* with the production of osteophytes,

FIG. 272.



Phosphorus-necrosis of lower jaw (Musée Dupuytren).

and is completed as a nearly total necrosis of the entire bone. That regeneration of bone is possible after the separation of the dead portion is shown in the specimen from which the accompanying figure was made. This, however, has only been noted in the lower jaw, and rarely if ever in the upper. The trouble appears first as an odontalgia, with swelling of the gums, bleeding at the gingival margins, later with extension of pain and swelling and pyorrhœa alveolaris; finally

FIG. 273.

Phosphorus-necrosis of lower jaw, new bone-formation (Musée Dupuytren).

there occurs formation of fistulæ opening either within or without the mouth, with evident effort to extrude the dead portion of bone. *Submaxillary abscesses* often accompany the disease, and the ingestion of their purulent products leads often to disturbance of the digestive organs, as well as of the lungs by a sort of aspiration pneumonia. The disease occurring in the upper jaw is much more severe and of much less favorable prognosis.

PLATE XX.

Necrosis of Shaft of Femur with Sequestra, life size.

TREATMENT OF THE TOXIC FORMS.—The *preventive* treatment must consist of careful supervision of the teeth, the use of alkaline mouth-washes, inhalation of terebinthinate vapors, which neutralize those of phosphorus, and always the perfect ventilation of establishments devoted to match-making. The curative treatment consists of buccal antisepsis, opening of abscesses, and the removal of diseased bone, especially of dead bone, upon the first provocation. The occurrence of fistulæ should always be regarded as pathognomonic of diseased bone. In aggravated cases, such as are rarely if ever seen to-day since legislation has been brought to bear upon the subject, practically complete necrosis of the lower jaw, either *en masse* or in portions, was far from unknown, and the possibilities of regeneration of the bone was for a long time discredited, until the late James R. Wood of New York exhibited a specimen, both at home and abroad, which proved its possibility. Since then we have learned that it is possible for bone thus to regenerate, the cause of the disturbance having been removed.

Sequestrum-formation.—To the portion of bone which dies, be it large or small, regular or irregular, is given the name *sequestrum*, while multiple sequestra are by no means uncommon. The sequestrum is white and ivory-like in hardness—at least when it consists of original compact structure. It is rare to find a distinct sequestrum of

FIG. 274.

Central necrosis of tibia, long central sequestrum (original).

FIG. 275.

Sequestrum inside of a core of new bone-tissue, arranged much like a puzzle (original).

FIG. 276.

Necrosis of tibia, showing sequestra after removal (original).

spongy tissue, simply because this yields so readily to the presence of granulation-tissue and of pyogenic infection. A sequestrum may include an entire bone, shaft or epiphysis, or only a small fragment. A given portion of the bone, having lost its vitality, becomes properly a foreign

body which the surrounding tissues endeavor to extrude or to wall off and surround. The extrusive effort is the one which is usually seen. This is done by the continued presence of granulation-tissue, which gradually perforates the surrounding bone at places of least resistance, the result being the slow formation of a sinus or several sinuses, ultimately connecting with the surface, and in which in neglected cases the dead fragment of bone can be seen or felt, or from which it can be withdrawn almost without operation. While this weakening of bone is going on in certain portions, a corresponding strengthening process is also being put into effect; and the result is a quantity of new bone, which is often wrapped around the sequestrum or which is simply the effort to atone for its pathological weakness and to strengthen it, sometimes to an amazing degree. This new osseous tissue which so often surrounds the sequestrum is called the *involucrum*, and in many instances it is necessary to remove more or less of the involucrum before the sequestrum can be lifted out of its bed or removed.

The whole necrotic process is perfectly intelligible if simply read aright as an endeavor on the part of nature to get rid of dead and irritating material. When this effort is properly interpreted and early enough, the natural efforts can be seconded by the interference of the surgeon at a time when disturbance shall be limited to the minimum and before external sinuses have had any opportunity to form. On the other hand, ignorance and neglect may lead to the extreme condition, and most fantastic arrangements of sequestra and involucra are seen in all pathological museums, some of which seem to partake almost of the perplexities of Chinese puzzles. The explanation, however, is always as above afforded.

Fig. 277.

Necrosis of lower end of femur (original).

Diagnosis.—Diagnosis is rarely difficult, and in practically all cases can at least be made to the extent of recognizing when operation is called for. It is made partly by the history of the case, partly by the local appearances, which latter are in large measure those either of bone-tuberculosis, bone-syphilis, or bone-abscess, already described. Caries and necrosis alike call for operation, and, in view of their possible complications, it is not always easy to make a minute diagnosis.

Treatment.—This is always surgical, and consists in removal of the dead portions and restoration of the parts to a condition favoring rapid regeneration. The treatment must always be radical, and is made difficult sometimes by the inaccessibility of the fragment or by the density of the involucrum and the necessity for large external openings in order to remove the sequestrum.

A generation ago it was held inexpedient to attempt to remove bone until a number of weeks had elapsed, during which nature was supposed to effect its dislodgement or its loosening. There is, however, no reason for waiting, and dead or dying bone should always be removed as promptly as possible.

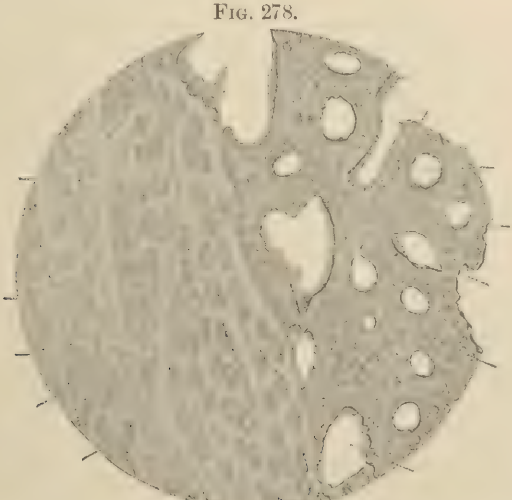
Large and powerful forceps and strong and well-tempered bone-chisels are usually necessary, while, after making the necessary opening for removal of the sequestrum, the sharp spoon should be used thor-

oughly to scrape away all the lining material of cavities in which fragments have been lying or all fungous tissue which may fill sinus tracks. It will be well after this to thoroughly cauterize the wall of the cavity, after which it is to be packed.

The packing of old bone-cavities is of importance, and operators should appreciate the reason for so treating them. The packing is essentially a foreign material which the tissues will naturally endeavor to extrude as they did the sequestrum. The method of extrusion is by filling up beneath and around it with granulation-tissue, which later may ossify. The packing is therefore a constant provocation to the formation of this tissue, which is now desirable and is used mainly for this purpose. It is antiseptic material, and will serve always to prevent decomposition of the pyoid material which would otherwise fill such a cavity as the result of waste—Nature's effort at formative material gone to waste. A number of years ago Gunn suggested the use of *wax* for this purpose, wax being plastic and incapable of absorption. A piece of white wax was heated in hot water, moulded with the fingers to fit the cavity, where it served the purpose of a packing, and was reduced in size with each dressing, as was necessary to permit it still to remain. It is not now used as much as it deserves to be.

In favorable cases it may be possible to so thoroughly cleanse the bone-cavity without the use of caustics as to justify the attempt, after rigid asepsis, of allowing it to fill with blood which shall coagulate and organize directly into connective tissue. When this effect is desired the wound should be covered with green silk protective, over which the other dressing may be snugly applied. This healing by the *aseptic blood-clot* is the ideal method when possible.

FIG. 278.



Junction of old and new bone, osteoblasts arranged both regularly and irregularly (Ollier).

It has been held for a number of years to be necessary to retain the periosteum in these bone operations as an essential bone-forming element. Of late, however, we have learned that the periosteum as such has no bone-forming power, but that it may preserve, adherent to it, some of the osteoblastic cells removed with it from the underlying bone, which themselves have the power of reproducing their kind. Subperiosteal operations, therefore, are not as highly regarded now as a few years ago. Nevertheless, when the periosteum is not diseased it is always well to preserve it. When diseased, however, especially when tubercular, it should be unhesitatingly removed.

The extent to which regeneration of bone is possible is often amazing, especially in the young. Thus, after removal of the entire shaft of a tibia there may be in time not a complete restoration to former integrity, but, nevertheless, the formation of so much new osseous material as to restore a great degree of strength, and which shall, with the compensatorily hypertrophied fibula, make the leg as useful as ever. In the thigh, however, complete necrosis of the femur will almost always mean amputation, as it will also in the arm unless the necrotic portion be but a small proportion of the length of the humerus. The treatment of necrosis of the skull, or, in fact, of any bone in the body which is accessible, is based practically on the principles already laid down.

Other Parasitic Affections of Bones.

These are mainly of two varieties—*hydatid disease* and *actinomycosis*.

Hydatid disease of bone consists in the development of hydatid cysts which may be either of primary or secondary origin. Almost all the bones of the skeleton are liable to cyst-formation, save only the very short bones of the carpus, tarsus, and digits. In the very long bones they occur most frequently in the region of the epiphyses. The particular vascularity of this region is the main factor in their location at this point. The cysts may be unilocular or multilocular, and around them may be a thin or a large area of infiltration. In other words, their boundaries may be abrupt or not. Their volume is exceedingly variable, unilocular cysts sometimes attaining considerable size and distending the bone out of all its normal proportions. (See Chapter XXVI. for further reference to the pathology of hydatid cysts.)

Hydatid cysts in bone pursue a most insidious course, and oftentimes their growth seems to be arrested and they remain stationary for long periods. Lesser has, for instance, reported a case remaining absolutely stationary for forty years. In the long bones indolence is characteristic, but may terminate in acute symptoms if the bones be fractured. On the other hand, in the flat bones there is a distinct new formation, circumscribed, compressible, and accompanied by a peculiar parchment crepitation which is considered pathognomonic of these cysts. Spontaneous openings are rare. When undisturbed these collections remain indefinitely indolent, but subject at all times to possible pyogenic infection. Spontaneous fracture of a bone is always a suspicious occurrence, and may lead to the detection of hydatid disease in the same.

Prognosis is not usually good. Although the infection is one of such slow course, the disease tends to advance rather than retrogress, and suppuration is frequent, while important viscera like the brain and cord may suffer compression.

The treatment is purely operative. The contents of the cysts must be evacuated and its walls radically destroyed by caustic, spoon, etc. All sequestra must be removed; in the limbs *amputation* is sometimes necessitated by the extent of the affection.

Actinomycosis (see Chapter VIII.).—The general character of this parasitic disease has been already considered. It should be remembered here, however, as one of the possible, though in this country rare, affections of the bones.

The peculiar fungus may be found in the periosteum, in the compact outer layers of the bone, or within its more spongy depths. When the lesion is large enough to be recognizable to the naked eye it assumes, for all practical purposes, the appearance of caries like that due to tubercular or leprous diseases, while in the pus or débris discharged from the same or contained within the invaded bones the characteristic yellow, cheesy, or calcareous particles will always be recognized.

In this disease there never seems to be the slightest tendency to encapsulation, nor to protect against further spreading by any process of repair. The diseased area constantly enlarges its dimensions, involving everything as it spreads, it being limited by no membrane nor tissue of the body. Occurring in the bones, it is for the most part a secondary or metastatic infection, and may be found in any part of the body.

The symptoms will be those of osteoperiostitis occurring first in the jaws, as it nearly always does in cattle and often in man; it will be accompanied by loosening of the teeth and involvement of the submaxillary tissues in a way scarcely imitated by any other disease. The course of the disease is always slow, with little or no tendency toward spontaneous recovery.

It requires mainly to be distinguished from tuberculosis of the bone and from syphilis. Occurring in deep locations, it may prove most puzzling. It is much easier to exclude syphilis by the history and by examination of the rest of the body than to exclude tuberculosis. If, however, pus or any discharge from the affected part can be secured, a careful examination of it will ordinarily permit a prompt diagnosis. It may also require to be distinguished from sarcoma of bones, which again may be difficult and perhaps possible only before operation, when the characteristic granules can be discovered in the discharges. When the limbs or accessible parts of the body are involved, however, these cases will always call for operation, and diagnosis can be then made if not before.

Leprosy.—While leprosy is not often included as a disease of the bones, it must not be forgotten that some of the most characteristic disfigurements of this peculiar disease are due to the lesions involving and subsequently destroying the bones, as already mentioned in Chapter IX. Leprosy is a specific infectious disease whose existing cause is a peculiar bacillus, but whose lesions, so far as structure is concerned, are practically those produced by granulation-tissue, which encroaches upon and takes the place of normal tissues, its own presence being provoked by the organisms at fault.

The picture of a leprous involvement of a bone is not different from that of tubercular disease of the same part, although there is in the former case little or no tendency to secondary infection and to ulceration or necrosis. In this respect lies the principal difference in the two diseases.

Trophoneurotic Diseases of the Bones.

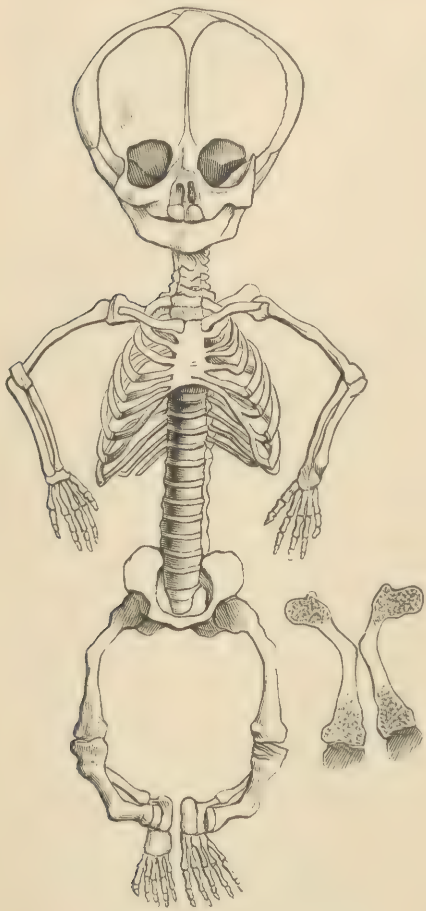
Under this general heading it is proposed to group a number of diseases whose clinical manifestations are distinct or classic, but whose underlying causes are as yet more or less obscure, in most cases more so, and about which we can speak with but little definiteness; nevertheless, the diseased conditions are distinctive and important.

Achondroplasia.—This is a lesion of intra-uterine life which includes a softening of primary cartilaginous structures and curvature or malformation of the bones which should be formed from them. It concerns that period of fœtal life between the third and sixth months. It has been sometimes spoken of as *intra-uterine rickets*. (In fact, the term rickets has been made to cover many different conditions.) Under this name it was first described by Müller in 1860, and since then by various authors under various names, most commonly as *fœtal rickets*. It appears that in this disease the fœtal cartilage contains mucus abnormally collected, for the most part, in minute cavities or cells just at its borders. The chondroblasts and osteoblasts are not regularly dispersed, and the development of the growing bone is thereby much interfered with. The periosteum appears to have nothing to do with this condition. In consequence the cartilage does not do its proper duty. The

long bones fail to attain their proper proportionate length, but become thicker than normal, the periosteum being unaltered. On the other hand, those bones into whose formation cartilage enters but slightly, such as the clavicle and the ribs, retain their normal proportions: the consequence is a peculiar malformation and disproportion of the whole skeleton (Fig. 279).

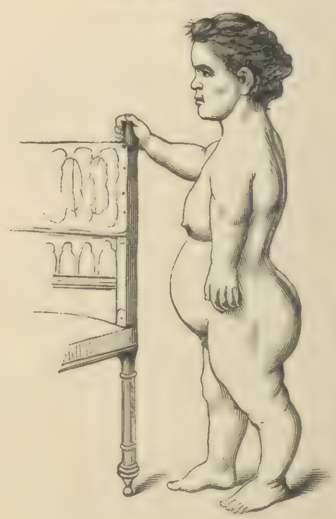
These deformities are symmetrical, and pertain for the most part to the bones at the base of the skull and to the long bones of the limbs; therefore the distinctive appearance may be recognized even at the birth of the child. The head is disproportionately large, the spinal column short, the lumbar curvature exaggerated, all of which is rather the reverse of the ordinary rachitic manifestations. The disease is not common (Fig. 280).

Fig. 279.



Achondroplasic skeleton (Porak).

Fig. 280.



Achondroplasia (Lugeol).

Prognosis is unfavorable, because it seems impossible to undo the faults of the intra-uterine condition. The disease, however, is not incompatible with a long life.

Rachitis.—This also is a constitutional condition, and has been already described in Chapter XIV. So far as the manifestations in the bones are concerned, it is a constitutional dystrophy caused by improper deposition of calcareous material in the softened and somewhat perverted fœtal cartilages. It is a condition, however, pertaining rather to post-

natal life, and while inconspicuous at birth becomes more and more marked as the child develops.

It is essentially a disease of malnutrition, and consequently may be seen in all walks of life, as well in the bottle-fed babies of the wealthy as in the best-nourished children of the very poor. The lesions are widely distributed. The disease is divided by some writers into three periods: (*a*) *rarefaction of bone-tissue;* (*b*) *softening of same;* (*c*) *re-ossification.*

The first stage is the intra-uterine part; the second and third stages are post-natal. To fœtal rarefaction have been attributed intra-uterine fractures, even by Hippocrates.

The general dyscrasia and visceral alterations of rachitis interest us here less than deformities of the various bones. The head is disproportionately large, the vertex flattened, the frontal and parietal eminences pronounced; the anterior fontanelle closes very late. To the atrophic alterations of the head have been given the name *craniotabes.* The face is disproportionally small, the lower jaw assuming a polygonal shape. The palatal vault is of the Gothic type, dentition irregular and retarded. In the thorax the clavicular curves are exaggerated, by which the bones are shortened and the shoulders made narrow. The costo-chondral junctions are enlarged, the result being the so-called *rachitic rosary.* The sternum projects and gives the peculiar appearance known as *pigeon-breast.* The pelvis is often deformed, frequently distorted to such an extent as in late years to make normal delivery impossible. The spinal column may either be distorted very early, or is likely to undergo alterations of curvature due to the combined results of pressure and traction upon softened vertebræ. The joint ends of the long bones are enlarged or clubbed, this being true even of the phalanges. Joint movements are often accompanied by crepitation. The axes of the long bones are distorted, and more or less marked deviations and curvatures result, giving rise to such deformities as knock-knee, bow-leg, etc., all of which are especially treated of in Chapter XVI. Vol. II.

It is these deformities especially which give rise to some of the most exacting operations within the domain of orthopædic surgery, while upon the skull, where those deformities are known to occasion defective development, operations having for their purpose the relief of pressure or expansion of a too slow-growing cranium have lately been extensively practised. (*Vide* Chapter I. Vol. II., Microcephaly.)

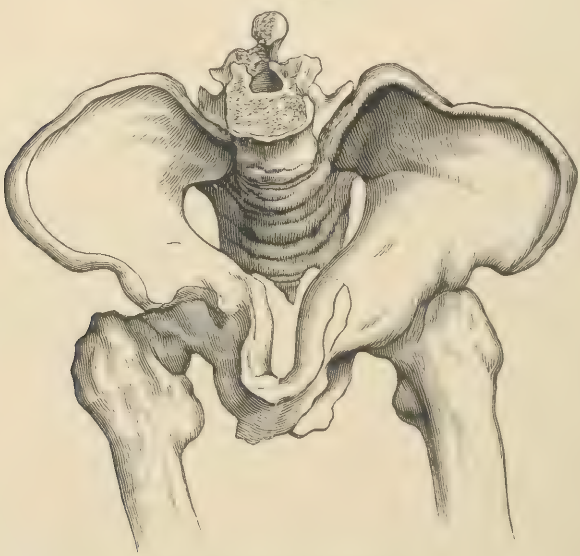
The *medical treatment* for these conditions is mainly the administration of calcium salts in solution, of which perhaps the best is the so-called compound syrup of the hypophosphites. When taken very early it is possible to accomplish much for these cases by a combination of proper nourishment with suitably directed gymnastic exercises and insistance upon such carriage of the body and such habits as shall permit a proper distribution of the body-weight. In this way much can be done in preventing deformity; but if it have already occurred it may be rectified by some one of the numerous operations elsewhere described within this work.

Osteomalacia.—As rickets is essentially a disease of the very young, osteomalacia is practically confined to adults. The name implies a peculiar *softening of the bones* by which their resistance and rigidity are weakened and deformity permitted. The disease is common to man

and animals in confinement, and is frequently noted among wild animals dying in zoölogical gardens. It is perhaps most often noted in *pregnant women,* where it would appear as if the mineral elements needed for the growing fœtus were abstracted from the mother's bones rather than from the food ingested. It is brought about also by *starvation,* possibly by *lactation,* especially among those who nurse their children for unusual periods.

The histological changes are slight, the condition being essentially an absorption of the calcium salts through the fluids in which the bone-elements are bathed. In consequence the bones are made more elastic and flexible and marked changes in their shape and form permitted. This is particularly true in the pelvis, where deformity takes place to an extent often calling for artificial delivery or even Cæsarean section (Fig. 281).

FIG. 281.



Osteomalacic pelvis (Mauclaire).

The theories advanced to account for osteomalacia are unsatisfactory and need not detain us here. Just what rôle the trophic nerves play is not made out with any definiteness. The disease is insidious, and deformity is frequently preceded by pains, usually nocturnal, often exasperating, for the most part referred to the muscles. Sometimes they are only produced by pressure or movement. They are almost invariably described by the patient as rheumatic. They are frequently accompanied by muscular cramps. There is an accompanying sense of general debility and muscle-fatigue. The tuberosity of the ischium becomes tender, and patients in consequence assume a horizontal position. All these signs may be obscure and the condition pass actually unrecognized until deformities begin to occur. Should they be complained of by a pregnant woman, careful pelvic examination should be insisted upon, in order that such deformity, as may render approaching delivery difficult or impossible, may be appreciated in due time.

In patients not pregnant the first deformity will probably be noticed in the vertebral column, while the pelvis will remain intact. Changes in the thorax and in the limbs are more easily appreciated and ordinarily earlier recognized. The adjoining figure (Fig. 282), taken from the Dupuytren collection, illustrates one of the most remarkable cases of this kind on record.

Spontaneous fractures, especially of the long bones, are frequent. These may refuse to unite properly, and false joints may result. The urine will under these circumstances contain an excess of mineral salts, carbonates, phosphates, and oxalates, and when these are discovered in the urine of those suffering from fractures it should always be a warning to administer calcium salts and mineral acids internally, preferably phosphoric, and to carefully watch the excretions.

FIG. 282.

Osteomalacia: celebrated case of Moraud, 1753.—Skeleton now in Musée Dupuytren.

The PROGRESS of the disease is slow, yet steady, and often not easily checked, if at all affected, by mineral acids. Occurring in pregnant women, it may be checked after delivery, especially if the child be not allowed to nurse from the mother. In some instances it occurs with each successive confinement in the same patient, and makes distinct advance with each fresh attack.

The PROGNOSIS is therefore unfavorable, least so in puerperal cases.

An *infantile form*, as well as a *fœtal form*, has been described, but it is doubtful whether these forms really come under the same category, and whether they are not manifestations of rickets. A *senile form* has also been described which affects for the most part the sternum and thorax, which is characterized by excess of nervous excitability and by bone-pains, as well as by liability to multiple fracture upon the slightest provocation. This form, however, differs but little from the osteoporosis of advanced years, and scarcely deserves distinct consideration. Certain writers have also spoken of a *symptomatic form* observed in cases of cancer, syphilis, scurvy, etc., which, however, is entirely unnecessary, since the fractures occurring in cases of cancer or syphilis are due to secondary lesions of the same character, while those occurring during scurvy are simply an expression of starvation and weakening even of the bones. Cases of cancer, for instance, where bones have broken without being previously weakened by secondary growths, have been described, but are exceedingly rare and need only to be mentioned here.

The TREATMENT for all these conditions must be removal of the cause if discoverable, and the administration of calcium salts in accessible shape, as in cases of rickets.

Osteopsathyrosis, or Fragility of Bones.—This seems to be a condition distinct from osteomalacia, just described, it being, more than the other, a condition due to trophic nerve disturbance. The condition seems to be hereditary, often extending through several generations. It is characterized by fracture of long bones upon the slightest provocation, and is a disease common to all ages. While apparently congenital in origin, it persists often throughout life, no impression being made upon the condition by medication. It is not characterized by distinctive histological changes, and all theories heretofore advanced toward its explanation are disappointing. We are as yet in complete ignorance as to its cause. It is seen, at least in this country, most often in *paretics* and *inmates of insane asylums.* The ease with which the bones of such patients are broken has given rise to repeated charges of violence or homicide. From one case in which this charge was made I secured specimens of the ribs, which were so fragile that they could be easily crumbled between the fingers. Such patients might easily sustain serious fractures when undergoing necessary restraint, even of the gentlest nature.

FIG. 283.

Osteopsathyrosis (Blanchard's case).

Osteopsathyrosis of this congenital type is perhaps best illustrated by a case reported by Blanchard of Chicago,[1] in the case of a woman twenty-seven years of age at the time of his report, who up to that time had sustained over one hundred fractures. In her case it was sufficient to merely gently slide from the sofa to the

[1] *Trans Am. Orthopædic Assoc.*

floor to break some bone. Treatment in her case had been of no avail (Fig. 283). It is important to impress these facts upon the mind of readers, because allegations of undue violence are frequently made in these cases, which, especially in asylums, may be most unjust and difficult to prove or disprove.

Senile Fragility of Bones.—This simply means weakening of the bones, which is incident to advanced age in either sex due to and comprised under the term *osteoporosis.* Added to this, in certain places is a positive change in shape, also characterizing the senile condition—*e. g.* the neck of the femur. Under these circumstances bones will break with a minimum of violence and without invoking any theory of osteomalacia, osteopsathyrosis, or the like. As bone disappears under these circumstances, fat usually takes its place, so that while the volume of the bone may be not particularly diminished, it weight and density are materially altered. (*Vide* also introductory remarks to this chapter.)

Atrophic Elongation.—This is a term first applied by Ollier, and refers to a distinct type of alteration in long bones by which their actual volume is relatively diminished, although they *increase in length.* It is produced largely by lack of pressure, and is seen in many amputated stumps, in which it has much to do with the conicity of the same. It is seen in another expression in certain cases of typhoid fever or in forced confinement of the young to bed, where the bones appear to grow at a much more rapid rate than normal. It may also be due to unequal amounts, or defects, of nutritive supply, especially that furnished by the periosteum, and in certain other cases seems to be a purely reflex or trophoneurotic change which is always inexplicable. Frequently accompanying it is muscular wasting, which is to be explained rather by reflex action through the cord, produced perhaps through the mechanism of the terminal filaments of the articular nerves.

Ostitis deformans, or, as it is often called, **Paget's disease of the bones**, is a condition found alike in long and flat bones, the osseous tissue being condensed in texture and increased in amount, or at other times the osseous tissue becoming quite porous and the spongy tissue rarefied without alteration in the marrow. It is due to the unknown causes which may be summed up in the expression trophoneurotic, a *painful* and a *painless* form having been described, the former the more frequent. It produces deformities, disfigurements, and hypertrophies of the long bones. It is distinguished from *arthritis deformans,* described in Chapter XXXIII., which is a distinct malady, this under consideration having no particular reference to joint structures.

In the skull it is usually the face bones which are most involved, although the disease often commences in the cranial bones. The skull proper may be thickened even to three centimetres. The thorax becomes globular or cubic in form ; the arms are relatively too long, and there is usually dorsal kyphosis ; the pelvis is thickened and distorted ; the ribs are augmented in size, the femora irregularly curved ; the patellæ enlarged ; the tibiæ more massive and their curves exaggerated. The disease is essentially a *symmetrical* one, commencing for the most part in the cranium and radius. Fractures are rare, because the bones become stronger rather than weaker (Fig. 284).

In many instances these changes are accompanied by severe pains, sometimes exaggerated by pressure. The malady is usually regarded as rheumatism, but it

must be said that, even were accurate diagnosis made early, it would scarcely avail in treatment, since there is none for it. It may require to be distinguished from hereditary syphilis, in which the tibiæ have more of the sabre shape; from *acro-*

FIG. 284.

Ostitis deformans (Paget).

megaly, soon to be described, or *leontiasis*, which begins in the bones of the face and involves the cranium only secondarily.

Osteoarthropathie hypertrophiante pneumique.—Under this title, which has no exact equivalent in English, was described in 1890, by Marie, a peculiar affection which is usually spoken of in this country as **Marie's disease.** This is for the most part a pulmonary affection accompanied by enlargement of the extremities. There is some reason to think that, whatever it be, there are present some micro-organisms giving rise to products that are absorbed into the general circulation, the result of whose presence is an irritative hypertrophy of certain parts, particularly the joints and ends of the fingers, the elbow-, shoulder-, and knee-joints, and often the wrist. There is also ordinarily dorso-lumbar kyphosis, which in acromegaly is usually cervico-dorsal. The cranium remains intact; the borders of the jaw are sometimes involved.

Clinically, it is characterized frequently by articular pains, occasionally by excessive perspiration and by certain cutaneous eruptions or pigmentations. In the bones involved are found areas of new bone-formation, and synostosis of adjoining bones is possible. It is most commonly seen in males of adult age. From Paget's disease and from acromegaly it is distinguished by not involving the head at all (Fig. 285).

Acromegaly is so named from its tendency to increase the volume of the bone extremities or apices. The first case of this disease was published by Marie in 1885. It is characterized by progressive increase in

weight, by enlargement of all the extremities, bones and soft tissues alike, but the most characteristic involvement is that of the lower jaw, the upper jaw being little if at all affected. The lower jaw assumes enormous size and projects so that its teeth are far in front of those of the upper. The supraorbital ridges enlarge, as do also the sternal ends

FIG. 285.

Osteoarthropathy (Marie).

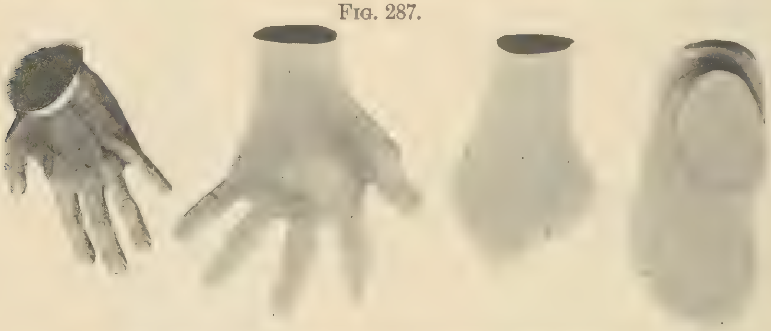
FIG. 286.

Acromegaly (original).

of the clavicles and costal cartilages. As the disease progresses the ribs are widened and the scapulæ enlarged, the vertebræ and the intervertebral cartilages thickened and fused together, causing usually cervico-dorsal kyphosis. The long bones of the limbs suffer later, especially at the lowermost joint ends—*i. e.* hands and feet. The viscera are rarely affected, but there is a peculiar and characteristic enlargement, usually of the thyroid and pituitary bodies. The lower cervical ganglion of the sympathetic is also sclerosed; the mucous membrane of the nose is usually hypertrophied; the uvula is enlarged, while often the larynx participates in the changes. Acromegaly is essentially symmetrical, and for each change upon one side of the body we notice a corresponding alteration upon the other. Particular features are observed in individual cases, but the above are practically common to all.

The underlying pathological condition is as yet undetermined, though most indications point to late alterations along the original *cranio-pharyngeal tract* of the young embryo, whose remains are best known in the pituitary body and the

FIG. 287.



Hand and foot of natural size contrasted with acromegalic extremities.

thyroid. The greatest complaint usually is of headache, which is difficult or impossible of relief. The disease is steady, progressive, unaffected by treatment, and the prognosis bad, though its course be slow.

Leontiasis.—A diffuse, bilateral, symmetrical hypertrophy of the bones of the face and later of the cranium, described first by Virchow, the real origin appearing to be in the superior maxillæ, the result being a peculiar leonine appearance of the face, whence the name given to the disease. There is no distinct tumor-formation in the bone, but rather

FIG. 288.

Leontiasis: skull of a Chinese woman (U. S. A. Museum, No. 10,620).

the entire structure of the bones involved is affected. As it advances—for this it always does—function of the parts is interfered with, mastication becomes impossible, headache and pain are constant. The special senses are disturbed because of involvement of their nerves, and patients

die usually from inanition, because no longer able to chew and swallow food. It is distinguished from Paget's disease, because it shows no tendency to involve the rest of the skeleton; from acromegaly, in which the general shape of the jaw is preserved, though its dimensions are magnified; from tumors of the jaw or face, because of its symmetrical enlargement. Its pathogeny is as obscure as that of the other bone affections mentioned in this list, and its treatment as unsatisfactory.

Tumors of Bone.

As between the various hypertrophic conditions of the bones just above catalogued we must distinguish the true neoplasms, which answer

Fig. 289.

Multiple exostoses, congenital (Fischer).

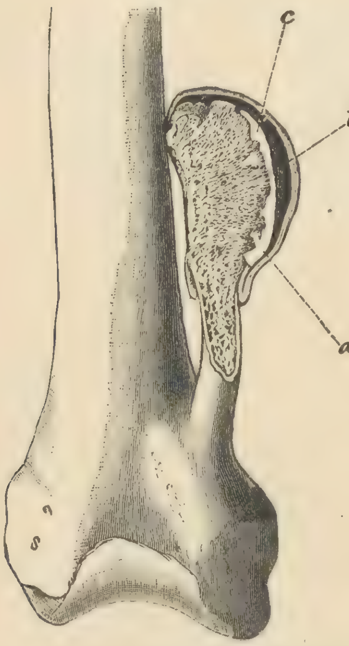
all the requirements of the definition given in Chapter XXVI., but which deserve special consideration here because of their importance. There are few if any of the true tumors which may not be met with in bone, including the periosteum.

Fibromata of even large size spring from the periosteum, especially about the jaws and from the base of the skull, from which latter place they may project into the nasopharynx and seriously interfere with the welfare of the patient. Some of these tumors are soft and succulent, as well as extremely vascular, and I have seen death occur upon the table in an endeavor to remove a growth of this kind, hemorrhage being simply uncontrollable.

Cartilaginous tumors, as stated in Chapter XXVI., are not often

found outside of the bony skeleton. They may spring from cartilaginous extremities of growing bones, from epiphyseal cartilages, or from the interior of long and short bones, where their origin is probably due to inclusion of cartilaginous elements, as comprehended in Cohnheim's theory. In young children they are often multiple and involve various parts of the body. Occurring in adults, they are less often multiple, but may attain considerable size. They are found most often about the ribs, sternum, pelvis, and femora. If the entire structure of a given bone be involved in a growth of this kind, its eradication—that is, amputation—will probably be called for. When otherwise, complete removal with careful cauterization of the base of the growth or surface from which it sprang will usually be enough. These cartilaginous tumors tend on the one hand to mucoid softening and cystic formation, and on the other to calcification or ossification, by which the original cartilaginous character of the growth may be concealed.

FIG. 290.

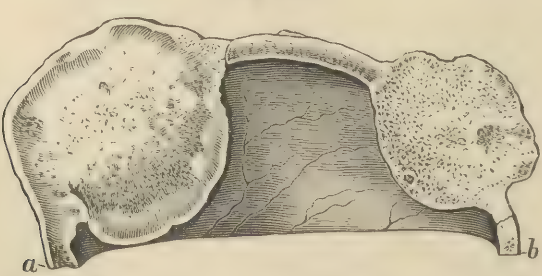


Exostosis bursata (Orlow).

Osteomata are by some writers made to include *exostoses* and *hyperostoses*. In accordance with the system adhered to in this work, only those growths are considered as tumors which are of no physiological usefulness, and I should prefer to maintain a distinction between osteomata and the exostoses (Fig. 289) or bone-hypertrophies, which pertain either to evolutionary relics or to constitutional affections.

There is, however, a peculiar form of exostosis which becomes covered

FIG. 291.



Cancellous osteomata springing from the diploë (Musée Dupuytren).

by an adventitious bursa, whose walls become in time quite thick, and which now goes everywhere under the name *exostosis bursata*. In the

cavity of this bursa will be frequently found rice-grain or other fibrinous concretions. This lesion is common in the neighborhood of joints, and the new bursa frequently communicates with the joint-cavity (Fig. 290).

Osteomata are of all degrees of consistence, from the softest spongy bone-tissue to the densest ivory growth. They partake in character of the nature of the bone in which they originate. They give pain only ordinarily as they cause pressure upon nerve-trunks. Other disturbances may also be caused by pressure.

These tumors also may be multiple, though usually single; no part of the osseous skeleton is exempt. Ingrowths from the cranial bones may produce all the signs of brain-tumors (Fig. 291). They call always for operative interference, which may be simple or most dangerous in accordance with their site and size. Very often amputation or resection is necessitated.

FIG. 292.

Sarcoma of femur (original).

FIG. 293.

Fungating osteosarcoma of cranium (Pemberton).

Myxomata are rare in bone, and are seen usually only as degenerated forms of cartilaginous bony or malignant growths. They lead to cystic degeneration. A primary growth of this kind must have for its origin the bone-marrow, such cases having been described.

Sarcoma of bone is often spoken of as **osteosarcoma**, the former term, however, being preferable. This occurs most commonly in the long bones, although none are exempt; usually single, it nevertheless

may be multiple. It occurs frequently in the young, is seen even at birth, and in these instances is supposed to take its origin usually from epiphyseal structures. No period of life is, however, exempt. Tumors attain sometimes enormous size. Marsh has recently described such a tumor weighing thirty-three pounds. Microscopically, these tumors may assume either of the varieties, those of the most rapid growth being found rather of the *round-celled* type, while those of slow growth are usually *myeloid* or contain giant cells.

Sarcomata frequently rise from the *periosteum.* Commencing in the interior of a bone, they are known as *intraosseous*, and as they develop, for the most part very slowly, they expand the bone more or less sym-

Fig. 294.

Osteosarcoma of humerus.

metrically, in distinction to those growths of external origin which are in evidence on one or another aspect of the bone involved. The former are also sometimes spoken of as *central sarcomata.*

They have to be distinguished for the most part from tubercular, more rarely from syphilitic, lesions. From the former they differ in that they do not produce the characteristic starting pains at night nor the characteristic muscle-spasm and muscle-atrophy. The type varies—deep circulation being, however, obstructed, there is often a superficial appearance strongly reminding one of tubercular lesions. So, too, the central form grows for the most part toward the epiphyses, tending to spread and involve joints in a way quite similar to tubercular affections. The general history and appearance of the patient must be carefully regarded in favoring one or the other diagnosis.

Sarcomata are peculiarly prone to *degenerations*, particularly *mucoid* and *myxomatous*, and *hemorrhages;* less so to *calcification* and *ossification*, and still less so to

pyogenic infection. In many of these cases, moreover, peculiar dendritic formation of new bone, or that in layers, is noticeable. The *pigmented* form of growth is exceedingly rare in bone; dissemination, especially to the lungs, is much more common; and the lungs are not infrequently involved in aggravated cases. This should often be taken into consideration before operating.

Sarcoma not infrequently has its origin from the callus of a delayed bone-union, and I have had repeatedly to amputate for this most unpleasant sequel of fracture. (See Fig. 297.)

As the disease advances there is increase of pain, usually with increasing cachexia, while augmentation in size of such a tumor may make a limb not only useless, but the source of greatest annoyance and difficulty in management of the case.

TREATMENT.—There is but one treatment in cases which will permit it—amputation of limbs, extirpation of tumors from certain bones, or

FIG. 295.

Sarcoma of periosteum of humerus (Pemberton).

FIG. 296.

Cystic osteosarcoma of tibia (original).

excision of entire bones. Thus for sarcoma of the scapula we extirpate the entire bone; for sarcoma of the skull we make extensive resections of the same, removing the underlying dura when involved; for sarcoma

of the upper or lower jaw we remove it in whole or in part. Sarcoma of the spine is inoperable, that of the pelvis for the most part equally so. In absolutely inoperable cases treatment by the toxines of erysipelas may be tested. In all the cases where pain is severe it is only humane to administer opiates, which under these circumstances are both anodyne, stimulant, and almost nutritive. Patients in this desperate condition should not be allowed to suffer, and opium in assimilable form should always be administered to any amount necessary.

Endothelioma.—We are hardly yet in a position to speak very definitely with regard to this growth, especially in bone, where, by the time it comes under observation, its original characteristics will have undergone more or less alteration. There is, however, good reason to think that some of the growths, especially of the softer variety, described as the central sarcomata, belong really among the endotheliomata. At all events, they are essentially malignant, and are to be treated in exactly the same way as the growths for which they are mistaken.

FIG. 297.

Sarcoma developing in callus (Haberen).

Epitheliomata and **carcinomata**, in general, being distinctly of *epithelial origin*, can never originate normally in bone. It is characteristic of these cancerous growths, however, that from surrounding structures they may spread to and involve bone, in which case we have an *epithelial infiltration* of the latter which is distinct and characteristic. Under these circumstances, and these only, is it possible to have true cancer of bone, save only in the rare cases in which it is of distinctly

metastatic origin, these latter being especially cases of cancer of the breast, in which we occasionally have metastatic foci even in the distant bones of the skeleton, but especially in the sternum.

Error in DIAGNOSIS can only here arise when the secondary disease is distant from the primary, but will be less frequent if the possibility of metastasis be borne in mind.

For such secondary or metastatic growths there can be but one TREATMENT, if any be possible—that is, merciless *extirpation*.

CHAPTER XXXVI.

FRACTURES.

By H. H. Mudd, M. D.

The term *fracture*, in surgery, is applied to a break or solution in the continuity of a bone or cartilage. Fractures are said to constitute one-seventh of all injuries. They are ten times as frequent as dislocations. This break may be a dent or an irregular depression, as frequently occurs in the flat bones. The bone may be compressed, as happens in the irregular bones, or the break may be a complete separation of the fragments of a bone with displacement.

In order to give accurate meaning to the term *fracture* one must modify it by a qualifying adjective or distinguish it by some phrase or name that will designate its characteristics. Thus we classify fractures, first, as **Incomplete** and **Complete**. Incomplete fractures may be subdivided as follows: (*A*) The *separation of an apophysis*, the *detachment of a fragment* by a cutting instrument, or the fracture of the malleolus. which, although exhibiting complete detachment of a portion of bone, is classed as an incomplete fracture because the body of the bone remains intact. (*B*) The *green-stick fracture*, which is the bending of a long bone, notably of the radius and ulna. This occurs only in young subjects. (*C*) The *fissured fracture*, which is a line of fracture extending partly across a flat bone, as the parietal, or a fracture in a long bone which does not completely sever a fragment from the body of the bone. In the long bones this fracture usually begins at the expanded end and extends into, but not through, the shaft. The line of a fissure may be spiral in its course. (*D*) A *depressed fracture* is a dent in the surface of a bone which is produced by direct violence. It may occur in the shaft of a long bone; is more frequent in the spongy bones, but it is most common in the flat bones of the skull. (*E*) *Partial fractures*. The green-stick fractures, the fissured and depressed fractures, are partial fractures, but there is a fracture which, although it may possibly be complete, comes properly under the designation of partial fracture. It is a fracture without mobility and without displacement. Crepitus is absent, but an injury to the bone is evident by impaired function, pain, and swelling. The swelling develops slowly as the osteoplastic deposit envelops the injured part. This partial fracture is frequently observed in the clavicle, but it occurs also in other long bones.

It may not be recognized for several days or until repair is advanced. If the patient is submitted to the close inspection of the surgeon soon after the injury, pressure may elicit slight mobility and possibly crepitus. This fracture affects children and young adults more than older subjects. The pathology of such frac-

tures is that of the simplest fractures. The periosteal covering may not be broken. If a bend is present, it may resist immediate effort for correction, but gradually under pressure or by nature's nutritive changes it is slowly eliminated. The adjustment of the fractured surfaces is practically perfect and repair is rapid. Recovery is sometimes so rapid and seemingly perfect that it might excite a doubt as to the existence of a break. Such breaks, however, do occur, and grave disaster may follow their non-recognition and neglect. By secondary bending or displacement they occasionally force the physician to a recognition of the wisdom of treating doubtful cases as fractures. The clinical symptoms may be limited to impaired function and a sensitive area over the bone.

Complete fractures may be classified as follows: (*A*) A *transverse* fracture is one in which the line of fracture makes a right angle with the axis of the bone or where it does not vary from it more than ten or twenty degrees. The surfaces must be so near a right angle that they

Fig. 298.

Transverse fracture, ununited.

Fig. 299.

Oblique fracture, badly-united.

will oppose each other, and not slip so as to overlap after adjustment. Irregular serrated surfaces often aid in maintaining the adjustment.

(*B*) An *oblique* fracture is one in which the line of fracture is at an angle of not less than ten degrees nor more than seventy degrees with the axis of the bone. It is intermediate between a transverse and a longitudinal fracture. The surfaces are at such an angle that even if they are well adjusted there is a disposition to overlapping. Any force

tending to shorten the bone, whether it be pressure or muscular contraction, produces displacement with consequent shortening. The fractured surfaces are disposed to slip one on the other until there is overlapping.

(*C*) *Longitudinal* fractures approach the axis of the bone, and may extend from one end of the bone to the other, or, entering at one end of it, may pass very obliquely through the bone to emerge at some distance from the point of entrance on one side of the shaft.

(*D*) The *epiphyseal* fracture is of course found only in the young subject, not after the twenty-first year. It is the separation of the articular end of the bone from the shaft; the separation occurs at the cartilaginous junction of the shaft and the expanded extremity. This line is transverse, except as it finds irregularity in the overlapping of a portion of the shaft, as at the tubercle of the tibia. The cartilaginous lamina between the shaft and epiphysis is not suddenly obliterated at one time, so that where the separation occurs at a time when it is partly ossified portions of the shaft or epiphysis are broken off, usually as thin scales of bone. It requires considerable force to produce such a fracture, and the damage inflicted is often increased by the stripping of the periosteum from the shaft.

(*E*) A *multiple* fracture occurs when there is a fracture at separate points of a bone or when there are several fractures in different bones at the same time. This term should not, however, be applied to the fracture of associated parallel bones, such as the radius and ulna or the tibia and fibula, when only one break in each is present, for they act as a common bone in resisting violence. A multiple fracture of a single bone implies that the fractured points are separate and are not close together. A bone may be broken into a number of fragments, but if the lines of fracture run one into the other and the fragments are comparatively small, it becomes a comminuted fracture.

(*F*) An *impacted* fracture is where one fragment penetrates the other and becomes imbedded in it. This fracture may occur in any part of a long bone, but is most frequent in the expanded extremity, where a point of bone is likely to be entangled in the cancellated bone. The interlocking of the fragments must be firm enough to give some stability to the parts and to resist free movement at the line of fracture. This occurs not infrequently at the trochanter of the femur and the lower end of the radius.

(*G*) A *compound* fracture is one in which the broken bone has a more or less free communication through the muscles and fascia with a wound in the skin. An incomplete fracture may be compound. A compound fracture may be produced by direct or indirect violence. Direct violence bruises and lacerates the tissues. Indirect violence forces the bone through the skin and soft parts. It is one of the most important complications of fractures. A gunshot fracture is, of course, always compound. If a gunshot fracture occurs in the shaft of a long bone, it is almost always accompanied with comminution of the bone, thus adding another complication to the fracture. If the ball enters the cancellated bone, the fracture may be very limited, and, notwithstanding it is a compound fracture, it may heal readily and inflict but little damage. The splitting and splintering of the shaft of a long bone by a bullet is a serious injury.

(*II*) The *intra-articular fracture* passes directly into the articular surface of a joint.

ETIOLOGY OF FRACTURES.—The strength of a bone is determined by its texture; hence the same bone in different individuals varies markedly in its resisting power. Compact bone substance is always stronger than spongy bone.

The form of a bone may predispose it to fracture. The long bones and the flat bones are more liable to fracture than the irregular ones. The function of a bone may predispose it to the violence which results in fracture; thus the forearm and leg are most exposed, but the single bone, the humerus, transmitting the violence of many falls to the body, is often fractured. The clavicle is in the same way subject to fracture.

The habits of life of the individual have much to do with exposure to accidents, the period of greatest activity being the time of the most frequent occurrence of fractures—viz. from the twentieth to the thirtieth year of life. Males are most exposed, and, although their bones are stronger than the bones of the female, they suffer more fractures than females do.

The age of the individual is a potent factor in the etiology of fractures. It is a well-known fact that the increased size of the medullary canal and the diminished thickness of the cortex of the shaft of the long bones that occurs in old age are predisposing causes of fracture. The atrophic changes occurring in the aged affect alike both sexes, but with this fragile condition of the bones of the aged the relative weakness of the bones of females becomes more evident in the marked increase in the frequency of certain fractures, notably those of the neck of the femur and of the lower end of the radius.

Rickets weakens very materially the bones and predisposes to fracture, though it so markedly limits the activity of the child that in many cases it protects from fracture by imposing conditions which prevent exposure to violence. The stumbling of rickety patients, however, inflicts many falls and consequent fractures. No doubt intra-uterine fractures are more frequent in infants where the fœtal bones are diseased, as in congenital rickets. Various constitutional diseases, such as scurvy, syphilis, and struma, disturb the nutrition of the bones and weaken them. Trophic changes resulting from diseases of the nervous system may change the bone so as to predispose it to fracture. Rauber found that the tibia of a paralyzed extremity weighed 6.6 ounces, and of the healthy extremity of the same subject 9.4 ounces.

Local *inflammatory conditions* of a bone, such as caries and necrosis, may materially weaken it. Atrophy of a bone, whether produced by disease, paralysis, senile changes, or disturbed circulation, enlarges the medullary canal, increases the size of the interspaces in the cancellated bone, and thus weakens the cortex of the bones, so that they have but little resisting power. Mollities ossium or osteomalacia is a disease of adult life apparently dependent upon trophic changes due to nerve lesions, pregnancy, or cancer. The outline of the bone is not changed. The medulla changes in character, so that it does not renew the disintegrating bone. The cortex is largely replaced by fatty material and the bones readily bend or break. The bones also become fragile from a condition of osteoporosis which results from an inactive life or malnutrition.

Syphilis, by the development of gummy tumors or a rarefying osteitis, may predispose the bones to fracture. Thus it is manifest that physiological as well as pathological conditions predispose to fractures.

The *immediate cause of fracture* is found in the violence of extraneous force or muscular action. Fractures from external violence are caused either by direct or indirect force applied to the bone. Direct violence may produce a fracture at any point to which it is applied.

Indirect violence usually produces a fracture at some particular point of weakness to which it is transmitted. It is apparent that the degree of violence necessary to produce a fracture will vary not only with different bones, but with the physiological and pathological conditions of the bone, together with the manner of the infliction of the violence.

Tillmanns gives the following in regard to the strength of the bone: "The tensile strength of the compact bone substance amounts, in the fresh condition and in middle life, according to Rauber and Messerer, to from 9.25 to 12.21 kg. (20.35 pounds to 26.86 pounds) for every square millimetre of cross-section; that is, it is about equal to that of brass and cast iron. Its resistance to pressure is still greater, being from 12.56 kg. to 16.8 kg. (27.63 pounds to 36.96 pounds) for every square millimetre of cross-section, being about double as much as that of wood, granite, or lead. The capacity to resist torsion amounts on the average to 8 kg. (17.6 pounds) per square millimetre of cross-section. The strength of the spongy bone substance is much less. The resistance to pressure of the spongy part of the condyles of the femur, according to Messerer, amounts to only 0.96 kg. (2.11 pounds) per square millimetre on cross-section; that of the body of the vertebræ to 0.84 kg. (1.84 pounds) in middle life, and in senility to only 0.22 kg. (0.48 pounds) per square millimetre of cross-section.

"Of especial practical significance in the etiology of fracture is the strength of the bone as a whole. The tensile strength of the humerus, for example, according to Messerer, amounts to 533 kg. (1192.6 pounds); of the femur, to 674 kg. (1482.8 pounds).

"For strength to resist pressure Messerer found the separate bones to be in the following descending scale: Tibia, femur, humerus, radius, ulna, clavicle, fibula.

"By pressure in the long axis there occurred a crushing fracture of the shaft of the tibia, for example, with maximum weight of 1650 kg. (3630 pounds); of the femur, in men, on the average, as a result of 756 kg. (1663 pounds); of the radius, in men, on the average, as a result of 334 kg. (735 pounds); and in women the radius broke as a result of 220 kg. (484 pounds) pressure. Frequently the break did not occur at the most exposed place—that is, the middle of the bone—but through the compression of an articular extremity.

"A great number of fractures, as is well known, are bending breaks (Messerer; P. Bruns). The ability of bones to resist this kind of force varies in the different periods of life, attaining the maximum in middle life. A bending fracture of the femur in men follows a pressure of 400 kg. (880 pounds), and in women a force of 263 kg. (578 pounds) produces a break.

"The torsion elasticity amounts to perhaps one-third of the bending elasticity. A torsion break of the femur, according to Messerer, follows generally as a result of 89 kg. (196 pounds) force, and the clavicle breaks on the application of 8 kg. (17.6 pounds).

"According to the experiments of Messerer, in most cases, with gradually increasing pressure upon the skull, the free diameters increased very little indeed. The diminution of the diameters in the direction of the pressure did not occur uniformly over the whole skull, but only the parts to which the pressure was applied yielded inward. In the sagittal direction the skull bore a greater burden than in the transverse. By transverse pressure there occurred a transverse break, and by longitudinal pressure a longitudinal break."

Direct violence may be inflicted either by the muscular action of the individual forcing the bone against a resisting body, or by an extraneous force driving the foreign body against the bone. The calcaneum may be broken by the direct violence of a fall, the heel coming violently in contact with the ground. A wheel passing over a limb, breaking it at the point of contact, inflicts direct violence to the part.

Indirect violence more frequently breaks the long bones than the short or irregular ones. It is evident that peculiarities in the mechanism of the violence are important factors in determining where the fracture occurs; for instance, a fall upon the hand may break the radius,

the ulna, the humerus, or the clavicle; so also a fall upon the foot may break the fibula, tibia and fibula, or the femur.

Weak points and *curves* in the bones help to determine the site of fracture. Certain important differences in the fractures produced by direct and indirect violence must exist. The damage to the soft tissues at the seat of fracture will be much less by indirect violence. The broken ends of the bones may lacerate the muscles, the skin, or the vessels and nerves, but the damage is not likely to be so great as in fractures produced by a violence which may bruise and crush all of the tissues surrounding the injured bone. Muscular action, unaided by external violence, may produce fractures. The olecranon and patella are the most frequent examples of this kind of fracture. The humerus and femur are not infrequently broken in this way. The humerus is thus broken in the act of throwing. It may also be broken by torsion, instanced by two men placing their elbows on a table with their forearms upright and interlocking hands, and each endeavoring to force the hand of his opponent backward toward the table.

The femur may be broken by a twist in kicking. These fractures occur as a result of comparatively little force, as the bones have but little capacity to resist torsion.

The compression of uterine contractions and external violence may produce an *intra-uterine* fracture. A congenital fracture is to be distinguished from a fracture produced during delivery by the traction and manipulation of the attendant.

The deformities produced by the displacement of the fragments of the long bones are designated as *angular* when the axis of the bone is bent at the break; as *lateral* when the fractured ends are displaced to one side, so that the axis of the two fragments are not in the same line, though they may be almost or quite parallel; as *longitudinal* when the ends overlap; and as *rotary* when a segment of the bone is turned upon its own axis. A wide *separation* of the fragments may occur by muscular action, as in the olecranon process of the ulna, or in the os calcis when the posterior extremity is detached and pulled up, or in the wide separation of the fragments of the patella.

The COMPLICATIONS of fractures are of two kinds, *immediate* and *remote*. The primary local complications are numerous; for example, the open wound, the extreme obliquity, the involvement of a joint in a fracture, injury to a contained organ, as in the fractures of the skull and thorax, comminution of the bone, or compound fracture with the implication of a joint. To these we may add great destruction of adjacent tissues, the injury of arteries, veins, and nerves, the intervention of the tissues between the fragments, the wide separation of the fragments, emphysema, and free hemorrhage. The constitutional complications of shock and delirium may be present.

The *secondary complications* may develop in simple fractures, but are more likely to follow complicated ones. These secondary complications are deformities, delayed union, and false joint or an ankylosed joint; or trophic changes, together with sepsis, thrombosis, embolism, or tetanus.

SYMPTOMS AND DIAGNOSIS.—The diagnosis of a fracture is often very easy, though in some cases it is extremely difficult even after the careful consideration of every symptom. The symptoms are both *sub-*

jective and *objective*. Some of them are pathognomonic, others only suggestive. In many fractures all of the symptoms are easily elicited; in others nearly all of them are absent. Even where most of them are absent the diagnosis may be positive. Symptoms such as pain, loss of function, and history vary in importance with different patients, though the fractures may be similar.

The points to be considered in the diagnosis of fractures are as follows: 1. The *history*; 2. *Loss of function*; 3. *Pain*; 4. *Crepitus*; 5. *Mobility*; 6. *Deformity*; 7. *Ecchymosis*; and 8. *Redisplacement*.

The *history*, to be complete, should include an inquiry into the existence of predisposing causes and also that of previous injuries. The immediate history of the accident includes the manner and the points at which violence was inflicted, as well as a statement of the degree of violence and the recognition of an audible snap. It is generally impossible to estimate the degree of violence, and very generally the snap of a bone, if any is produced, is unrecognized in the excitement of the accident. The character of the violence and the point of its reception are the most valuable items in the history. *Loss of function* almost uniformly accompanies fractures. Impacted fractures, as at the trochanter and an occasional simple fracture of the tibia or fibula and the green-stick fractures, may exist without total loss of functional activity. On the other hand, it should be remembered that temporary loss of function is sometimes produced by contusion, fright, and nervous disturbances.

Localized pain and *tenderness* are often important symptoms of a fracture. Pain on muscular movements of the limb or at a point where no direct violence has been inflicted is a valuable aid to diagnosis. Pain at a point where direct violence has been inflicted may be due to contusion of the superficial soft parts or of the periosteum. If the pain is referred to a limited area, is elicited only on pressure, and always at the same point, but without apparent contusion of the parts, it is strongly suggestive of fracture. The pain of contused parts is more likely to be vaguely diffused and not so fixed in its location.

Crepitus is the grating caused by rubbing the fractured ends together, and is recognized by the sense of touch as well as by being heard. It is pathognomonic of fracture, but is often absent, and in many cases should not be sought for, as the diagnosis is clearly established without it. The crepitus of rough bone surfaces rubbing upon each other is, in the neighborhood of joints, simulated by inflamed bursæ and by tenosynovitis. The crepitus of cancellated bone is softer than that of the dense bone of the shaft.

Abnormal mobility in the shaft of a long bone is a positive symptom of fracture, but where the injury is near a joint it is sometimes extremely difficult to differentiate between the motion of the joint and the mobility of a break. This is especially true about the elbow and the hip, and it may be only after repeated trials or by the existence of crepitus that one can say surely there is abnormal mobility. Abnormal mobility is determined by manipulation, unless spasm of the muscles or voluntary movements exhibit it. It is absent in an impacted fracture and in a green-stick fracture, except where manipulation breaks the interlocking fragments apart. Roughly moving the fragments inflicts damage upon the contiguous tissues and pain upon the patient.

Deformity is one of the most important symptoms of fracture. It may result from the swelling of the soft parts or be dependent upon the displacement of the bones. The swelling is due primarily to hemorrhage, later to the infiltration with serum and lymph of the tissues surrounding the fracture. The deformity resulting from displaced bone may be a shortening, an angular or lateral displacement, a rotary displacement in the long bones, or an indentation of the irregular or flat bones. It is often pathognomonic, telling not only of the fracture, but suggesting more or less clearly its character. A wide separation of fragments may occur in certain fractures, as in those of the patella and the olecranon process. A careful inspection and palpation without movement of the injured parts, will often give the surgeon accurate knowledge concerning the situation of the fracture, the character of the violence, and the extent of the injury to the soft parts, and suggest the manipulation and the treatment required in a given case.

The two sides of the body should be compared in order to make measurements, expose symmetrical parts, and define the relative position of important landmarks, so that the deformity may be fully appreciated, for, though often most palpable, it is frequently so slight that the most careful investigation is necessary to reveal its presence.

Ecchymosis is sometimes distinctive of a fracture. An incomplete fracture may be suspected after injury if a point of pain exists where no direct violence has injured the soft parts, followed by the gradual development of ecchymotic areas at or some distance from the location of the pain. The blood follows the planes of the fascia, and is not evident until these lead it near the surface of the body. This symptom is especially valuable in the diagnosis of the fractures of the base of the skull, particularly of the posterior fossa.

The existence of these symptoms may be more or less fully established without manipulation of the patient. It is important that all the facts in the case be made clear with as little handling of the parts as is compatible with security.

It is a well-known fact that a dislocation once reduced generally keeps its place. This is not so with the majority of fractures, for they require extension and retentive apparatus to keep them in place. The re-establishment of a deformity after its correction is a valuable symptom and suggests the existence of a fracture.

TREATMENT.—Bones so uniformly unite when properly treated that an exception to this rule needs explanation. The treatment of a fracture is a great responsibility, and every surgeon knows that in certain fractures it is difficult to get a perfect result; hence dissatisfaction between the patient and the surgeon is not infrequent. Every effort must be taken to give each case careful attention, and the treatment must include both local and general conditions. The local treatment involves two most essential points—the reduction of the displacement or correction of the deformity, and the retention of the fragments in their normal position.

The *reduction of the fracture*, the "*setting*" of the bone, should be accomplished as early as practicable. In many cases it may be done at once, but in others it is better to wait until the patient is at home, where he can be kept quiet and where efficient treatment may be enforced. It is very rarely necessary to wait for the swelling or tumefaction to subside. This traumatic swelling subsides much more quickly and certainly if the adjustment of the fracture is promptly accomplished.

The perfection of the adjustment may be confirmed or established after the swelling has subsided, but it must, in part at least, be accomplished at once. Success in many fractures is best attained by prompt and efficient reduction.

If the injury to the soft parts is excessive and danger of gangrene is imminent, it may be wise to limit the effort at reduction to simple continuous extension with or without lateral support. The stability given to the injured parts by lateral supports is usually, even in these cases, a safeguard rather than a detriment, as its prevents excessive swelling, favors absorption, and diminishes the irritation produced by displaced fragments. Even in crushing injuries, when the extremity can be saved, it is extremely rare to find a case that demands a delay of several days in the adjustment. The effort to reduce displaced fragments or to set the bone should be carefully conducted. The surgeon should avoid in his examination undue manipulation, and above all things he must not add to the injury already inflicted.

The application of heat and cold, as also the use of liniments and medicated washes, is of secondary importance. However soothing they may be, they cannot be of much use if the bones remain displaced, irritating the soft parts, exciting muscular spasm, and destroying tissues by pressure. Moist heat applied to stimulate the circulation and aid in maintaining the vitality of the contused parts is perhaps the most universally advantageous. Cold compresses and ice-bags must be cautiously used, for, while they limit the acuteness of the reactionary processes, they may so depress the vitality of the injured tissues as to determine necrosis.

Muscular contraction is the first obstacle to the reduction of a fracture. This is to be controlled by traction and counter-traction, rarely by anæsthesia. Anæsthesia is more frequently demanded for diagnostic purposes than for the adjustment of fracture. The temperament of the patient often determines the necessity for its use. It is demanded in cases of doubt. The stage of muscular excitement which so often precedes the relaxation of full anæsthesia is at times a serious disadvantage in treating patients. Gentle traction, often necessarily continuous, aided by the knowledge of the fracture obtained through inspection and the history of the accident, will enable the surgeon to set the bone without much pain and with a minimum amount of manipulation and injury. If the fracture is oblique with overlapping or transverse with angling, extension is often all that is needed. If it is transverse with lateral displacement, it will need not only extension, but careful manipulation with pressure. The interposition of muscle and fascia and impaction occasionally resist proper adjustment.

The **retention of the fragments in position** after they are adjusted may be easy, but it will often tax the ingenuity and tact of the surgeon to the utmost to maintain even a fair approximation. Surgeons should remember that slight motion at the seat of fracture does not interfere with repair. Absolute immobility is not necessary for good and rapid union. The ribs, the clavicles, the femur, and the humerus are constantly in evidence on this point. Extension and counter-extension without lateral supports may be all that is necessary. Rest and an easy position secured by lateral supports and slight pressure are efficient in many fractures of the forearm and leg. A fractured bone may usually be kept in good position without being subjected to undue lateral pressure.

The union will not be good unless the fragments when at rest are properly adjusted; hence the retaining apparatus must so utilize the principles of extension and lateral support as to accomplish this purpose.

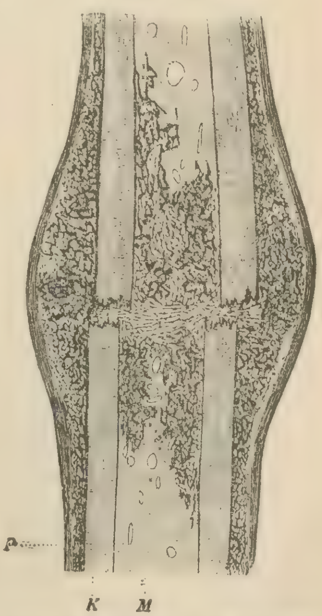
Repair of Fractures.

The repair of a fractured bone is by the formation of new bone-tissue. This new bone is ultimately perfect in its character. It is rare that union fails or that untoward morbid processes are engendered by a fracture.

The amount of new bone formed about a fracture is greater in the shaft of a long bone than in its epiphysis or in the flat or irregular bones. It is increased when the adjustment is imperfect and when the fragments move so as to increase the amount of irritation.

The histological changes and clinical phenomena which accompany the healing process are uniform. The character of the bone fractured and the complications encountered may alter the orderly process, but not the method, of repair. A fracture is uniformly accompanied by more or less hemorrhage from the bone and soft parts, the amount being dependent upon the location and character of the fracture and the extent of laceration of the contiguous tissues. This blood-clot plays a part in the generation of bone that is to follow only in that it gradually disappears, and is replaced by a soft vascular mass, the so-called *germinal tissue*, which envelops the bone at the seat of fracture. The cells in the vicinity of the fracture begin to multiply and new tissue is generated (see Fig. 300). This tissue is rapidly vascularized if the fracture is in cancellated bone, as in the flat and irregular bones and in the expanded ends of the long bones. Medullary tissue is found not only in the central cavity of a bone, but also distributed throughout the cancelli of bone, and under its influence and that of the periosteum a small amount of new material is converted rapidly into bone-tissue. It does not, necessarily, become first cartilage and then bone. The bone-cells, or osteoblasts, are found in small irregular cavities. Lime salts are deposited in the fibrous matrix of the new bone. The bone-tissue first formed is soft and coarse, taking a long time to become firm, hard bone of normal vascularity and density.

Fig. 300.



Fracture three weeks old: periosteal and medullary callus partly ossified, partly cartilaginous: *P*, periosteum; *K*, bone; *M*, medulla (Tillmanns).

The fibrous mass which develops about a fracture in the shaft of the long bones is quite abundant and forms a large plastic mass, which lifts the periosteum from the bone and envelops it both on its superficial and deeper surfaces. It forms a film between the firm broken edges of the cortex which connects this external envelope with the plastic osteoid substance which fills the medulla. The part of this plastic mass which immediately surrounds the break is generally converted into cartilage before calcareous or ossific matter is to be found in it.

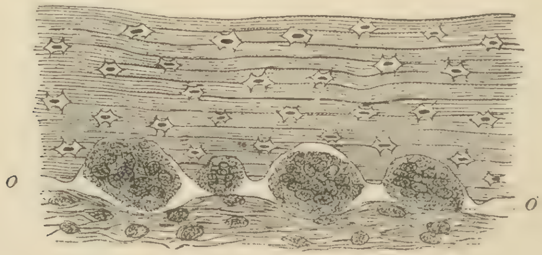
This fibrous mass or callus envelops the bone, extends in a thin lamina between the ends of the bone, and occupies the medullary canal for some distance above and below the site of the fracture. The portion within the medullary cavity is called the internal callus, while that between the ends of the bones is the intermediate callus.

The periosteum is buried in the new deposit. That portion of the periosteum near the periphery of the callus is the part which is vascularized first. Here the circulation is most perfect, and the osteoblasts are first found. The vascular supply from the periosteum is most free, and the blood-vessels extend from it into the callus. The blood-vessels from the bone emerging from the Haversian canals also permeate it.

The periosteum is the most active osteogenetic agent, but the medulla is also very active. The thicker portions of the callus immediately surrounding the break where the blood-supply is slowest in being perfected becomes cartilaginous. The blood-vessels must permeate this cartilage before it is converted into bone. Osteoblasts are not found in cartilage except under the direct influence of and in contact with blood-vessels. A zone of osteoblasts penetrates the cartilage about the blood-vessels, and then the osseous tissue is formed around them, so that, though neither cartilage nor blood-vessels alone are capable of forming bone, the two, together with the aid of the osteoblasts, accomplish this end.

The ossification of this callus occupies from four to eight weeks. During this time the broken ends of the bone still present a hard, rough line and have undergone but little change. The Haversian canals with their blood-vessels are, however, growing larger and the bone more porous. The spaces become large and irregular in outline and are filled with *osteoclasts* or giant cells. These large cells are destructive and not conservative. The bone-tissue is riddled with holes. A rarefying osteitis is established which continues until the ends of the bone are more like cancellated bone.

FIG. 301.

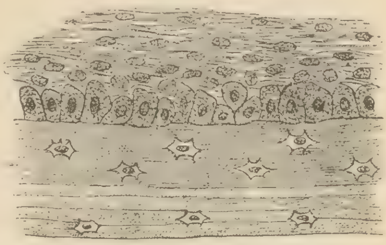


Lacunar bone-absorption by osteoclasts (Tillmanns).

As blood-vessels permeate the thin cartilaginous or osseous lamina between the ends of the bone, this lamina and the bone ends become highly vascularized. The rarefying osteitis thus established precedes the reparation of the break by new bone-tissue now to be formed between the broken ends. The new porous bone already enveloping the fractured surfaces and the bone occupying the medulla are becoming more dense. The spongy bone which now forms the ends of the fractured surfaces becomes less vascular. Osteoblasts replace the giant cells which have absorbed the dense cortical bone, and it again becomes more compact. The two surfaces are joined by bone, open and porous at first, but becoming denser as the active nutrient changes subside and the osteoclasts disappear, which were so necessary in preparing the bone for the vascularization essential to the formation of the bone required to unite the fractured surfaces.

Pathologists differ concerning the origin of osteoclasts. "Kölliker states that they are derived from the osteoblasts; Wegner, that they are formed out of adventitia cells; Von Recklinghausen, that they come from the white blood-cells; but, according to Pommer, the osteoclasts do not arise alone from the osteoblasts, but from the adventitia cells of the blood-vessels, from the perivascular endothelium of the lymph-spaces, and from the Haversian blood-vessels. In short, the protoplasm of all the cells which lie in the vicinity of the bone can under certain conditions take on the functions of osteoclasts. The origin of the osteoclasts is varied, so also is their final disposition.

Fig. 302.



Periosteal bone-formation by agency of osteoblasts: *c*, old bone (Tillmanns).

"The action of the osteoclasts is altogether local. The bone disappears under their effect, forming small excavations which are enlargements of Howship's lacunæ (Fig. 301). The osteoclasts probably generate carbonic acid by which the lime salts are dissolved. The remaining ground structure is assimilated, and taken up by the osteoclasts or resorbed by the blood- or lymph-stream."[1]

Osteoblasts are seen next to the bony trabeculæ which form the walls of the granulation-spaces (see Fig. 302). Laminæ of bone are deposited, and a condensing osteitis takes place, so that after many weeks the bone surfaces are reunited by dense, firm bone.

The osseous tissue that still occupies the medulla and forms the mass which envelops the bone, and produces the thickening at the seat of the fracture, is now to be absorbed and removed. This is slowly accomplished, the medullary cavity is re-established, the external callus is absorbed, rough points are rounded off, and the evidences of injury slowly disappear.

If the fracture cannot be made immobile or is imperfectly adjusted, the orderly process described is interrupted. The amount of new material necessary to unite a fracture under these conditions is much greater and the time required is increased. The healing process is delayed or completely interrupted, just as it is in the soft tissues when they are pulled apart or disturbed by motion or imperfect adaptation. There is also more scar and the deformity is increased. The callus is thick and abundant when union occurs under such conditions.

Osteophytes may develop during the healing of a fracture. They are most apt to spring from points of tendinous insertion or from misplaced pieces of periosteal tissue.

It must not be understood that the fractured surfaces are unchanged until the provisional callus which constitutes the primary union is fully organized. The rarefying osteitis which precedes the solid union of the cortex of the long bones begins soon after the injury, but the vascular canals are plugged with blood-clots and the process of vascularization is slow. The collateral circulation which is to be developed in the bone requires time. It is so slow that the bone is united by the surrounding callus, and is firm enough to resume its function before ossific matter has transformed the intermediate callus into bone of normal structure to complete the repair.

The **repair of intra-articular structures** is modified by the synovia and the cartilaginous lamina over the surface. Cartilage is not developed to repair the break in its surface. The line of fracture

[1] Tillmanns, vol. i. p. 499.

remains either as a sulcus with the bone at the bottom of it, or it has a thin fibrous band at the depth of the sulcus bridging the line of fracture. Intra-articular fractures are said to be more liable to non-union; this, however, is not well established, for union generally occurs.

The **union of epiphyseal fractures** takes place rapidly. The line of fracture follows generally the epiphyseal line, but frequently varies slightly from it, for scales of bone are found adherent to the cartilaginous line. If the irritation and inflammation are excessive, the cartilage may be destroyed or converted into bone. Hence the growth of the bone in length may be arrested. This seems to be the exception, however, and not the usual result.

Compound Fractures.

The TREATMENT OF COMPOUND FRACTURES is of the greatest importance. Antiseptic and aseptic surgery has completely revolutionized the practice of surgeons in caring for such wounds. The first essential in the treatment of such an injury is that the surgeon shall approach it with perfectly clean hands. The area about the wound should be rendered aseptic by the use of the razor, soap and water, and antiseptic washes. The wound should not be hermetically sealed when the injury is severe and complicated by comminution and contusions. Let the wound serve as an avenue for drainage. Gauze dressings may materially aid in making drainage free and safe.

In a large percentage of cases produced by direct violence, where extraneous matter has been forced into the wound, it is better to anæsthetize the patient. The wound can then be more thoroughly cleansed and inspected. This inspection means that the opening should be enlarged or that other openings be made that will permit of a thorough recognition of blood-extravasation, of the laceration of the soft tissues, and of the degree of comminution of bone. Loose fragments of bone should be removed and lacerated tissues, if their vitality be much impaired, should be trimmed off. Large blood-clots should be evacuated, and especially is this true if they are in the subcutaneous tissue. The fractured ends of the bone are to be adjusted. The wounds are then to be partly closed, an angle usually being left for drainage. It is not often necessary to use drainage-tubes, and rarely for more than two days, if primary union is to be attempted.

Even if the wound is clean, small, and the injury to the soft parts slight, it is safer to dress it as an open wound with an abundant pad of gauze over it. The dressing, no matter what material is used, should not expose a moist surface to the air, for this favors contamination and infection. Absorbent dressings should be abundant, for it is not wise to disturb unnecessarily the fractured bones if possible to avoid it, but cleanliness must be maintained.

It is very rarely necessary to wire fractured bones together in order to maintain apposition in compound comminuted fractures. It may be necessary to remove fragments and cut off sharp ends of bone, so as to facilitate adjustment, but the fracture can usually be retained in position without sutures. There are many compound fractures of the extremities, especially when produced by indirect violence, which after cleansing,

removing fragments of bone and blood-clots, can be safely closed, and union will occur promptly. However, in the hands of the average surgeon drainage is a safeguard.

It requires more time for compound fractures to unite than for the union of simple fractures, but the nutritive changes are essentially the same. The formative material consists first of soft tissue rich in cells, which gradually, through the ossifying activity of the periosteum and medulla, is converted into bone. It should be the rule to inspect such fractures at proper intervals until they become fixed in position. Any one who is competent to make a first dressing for a compound fracture is able to inspect it without special danger, and he can be more certain of good adjustment and perfect position if it is inspected a week after the first dressing. The external wounds can often be benefited by a renewal of dressings. The progress of the wound toward recovery will of course determine the frequency of the dressings and inspection.

Amputation is only justified in the gravest of compound fractures. There must be not only severe injury of the bone, but extensive laceration of the soft parts or grave interference with circulation before it is justified. Generally, the function of the limb must be fully compromised to justify it. Aseptic surgery makes it possible to save almost all cases even where joints are invaded. If joints are freely drained and kept aseptic, they bear severe injuries well. The adjustment should be made as perfect as possible. The joint being opened does not in itself justify amputation.

Delayed Union and Non-union.

The formative power of bone is very great and repair is usually most perfect. Nutrition of bone, its normal waste and repair, as also its regeneration after injury, are influenced by the general condition of the patient. Pregnancy, lactation, general debility, and acute diseases may interfere, just as an exhausting hemorrhage or a great physical drain may interrupt the process. There are certain local conditions which delay or prevent union—viz. marked displacement, the intervention of muscles and fascia, or a foreign body. Suppuration may destroy reparative material. Defective nutrition, either through innervation or deficient blood-supply or disease of the bone, may arrest the reparative process.

Certain bones and definite parts of a given bone are more liable to such interruption than others. The humerus, the bones of the leg, the femur, and the bones of the forearm are, in the order given, most liable to non-union.

A careful distinction must be made between *delayed union* and *non-union*. Union may be so delayed that at the end of the first, second, or third month the plastic deposit is deficient in amount and very soft. Stimulation of the nutritive process by rubbing the bones roughly together, or by puncturing the fibrous material as well as the ends of the bones with a drill, may arouse renewed action and secure solid union. The establishment of more perfect circulation or the improvement in the general health effected by getting the patient out of doors and by renewing his activity may start anew a halting reparative process.

In *non-union* the ends of the bone are rounded off, the medullary cavity is closed, the blood-supply to the seat of injury is diminished, and the ends of the bone at times may be widely separated by the absorption of bone. Non-union occurs very rarely—according to Hamilton, not more than once in five hundred fractures. It must be apparent to surgeons of large practice who have studied the clinical his-

tory of fractures that the *treatment of the fracture has much to do with the failure to unite.* Undue pressure, too light bandaging, over-anxiety about the process of union making the surgeon over-zealous in inspection of the parts, imperfect adjustment, and undue mobility, are all elements which should be considered. The surgeon should carefully consider every detail of his management of the case, as well as the local conditions pertaining to the fracture and the general condition and surroundings of the patient, before accepting the non-union as being predetermined by conditions beyond his control.

Age cannot be said to interfere with union of bones, for the general fact that fractures unite readily in the aged is daily verified by results. It must also be firmly impressed upon the mind of every surgeon that cases exist in which the nutritive conditions cannot be controlled by the most skilful management. These cases may come from chronic disturbances in health, from acute diseases and infections which may find in the fracture a seat for suppurative action. Complications may arise in which it is impossible to maintain local conditions which favor reparative changes.

Again, without visible reason *absorption* or *atrophic changes* may be excited in the bone instead of new deposits for regeneration and union. Even after the bone has been apparently well united the absorption process which removes redundant tissue may take place too rapidly and the bone bend, or fibrous material replace bone-tissue until a false joint is established. The diagnosis is not difficult: mobility, loss of function, wasting of the limb from non-use, and the pain are the symptoms.

The purpose of *treatment for delayed union or false joint* is to re-excite the activity of the nutritive processes. The procedures adopted for this purpose are varied. If the mobility is slight, as is often the case in fractures of the leg and the thigh, lateral supports may be adjusted and the patient allowed to use the limb. The continued irritation of the intermittent pressure exerted in walking renews and maintains active nutritive efforts until union is finally accomplished. Where there is much atrophy of the soft parts massage exerts a good influence. The Brainerd method—viz. boring the ends of the bone—is a safe procedure if performed as an aseptic operation.

If these simple methods fail, then the false joint may be exposed by a free *incision*, the tissues, whatever they may be, that intervene between the ends of the bone cut away, and the medullary cavity opened by resecting the bones in such a way as to give good broad surfaces for approximation and easy retention. It is important in the operation to so arrange the local conditions as to give full approximation and easy retention. This approximation may be secured by nails, wire sutures, ivory pegs, chromicized catgut or kangaroo tendon, or simply by a splint. The individual case must determine the necessity of the use of the suture. It is not always necessary. It usually requires a much longer time to secure union in such cases than it does in primary fractures. The periosteum from the portions of the bones excised must be saved.

SPECIAL FRACTURES.

Fractures of the Nose.

The nasal bones increase rapidly in strength and resisting power as they approach the os frontis. The nasal spine of the frontal bone rein-

forces them at this junction. Fractures of the base of the nose are infrequent, but quite dangerous. The cribriform plate of the ethmoid is very apt to be implicated in this fracture, the fragments of which very easily penetrate the brain. Inflammation and sepsis are apt to follow, for the spiculæ of the cribriform plate are sharp and the communication with the nasal fossæ offers a good opportunity for septic infection. The fracture may include the nasal process of the superior maxilla and the vomer. A broken nose is not dangerous to life, except when it is broken at the base and complicated with fracture of the cribriform plate. The break in the lower segment is most frequent, the injury being to the nasal bones only, though the perpendicular plate of the ethmoid may be bent or broken. The fracture is always by direct violence, is frequently comminuted, and often compound both by wound of the skin and the mucous membrane.

The cartilages of the nose are frequently separated from their attachment to the nasal bones. This accident is of the same clinical importance as a fracture of the nasal bones in their lower segment. Hemorrhage is occasionally severe, recurrent, and prolonged.

Deformity by deviation to one side or a flattening of the nose, crepitus under pressure, mobility, obstruction to the nasal passages by blood-clots, swelling of the mucous membrane, and the history of the accident are the common symptoms of these fractures.

Emphysema of the eyelids or cheeks also indicates fracture of the nose, and, although it may conceal the real deformity of the displaced bones, it is not a serious condition and rapidly subsides. It is produced by the escape of air from the nose in the act of sneezing or blowing. Bleeding into the subcutaneous tissue and the swelling from the contusion of the soft parts may also conceal the exact nature of the injury.

The deformity produced by an irregularity in the outline of the nose makes these fractures of extreme importance, and an accurate adjustment of the comminuted bone is necessary to the symmetry of the part. Any irregularity in the outline is most obvious and changes the whole expression of the face. If the displacement is marked, the adjustment can be accomplished best by force applied from within the nostril, a firm knitting-needle or a small grooved director serving very well for accomplishing this purpose. It is well to wrap it with iodoform gauze or plain sterilized gauze, which should be firmly applied to the bar, and the whole should not be more than three-sixteenths of an inch thick. This is to be carried upward and backward along the septum until it passes beyond the break, and then carried firmly and strongly forward until the bones are pushed and moulded into position. In order to accomplish this it should be carried forward along the septum parallel with the nasal bones until it rests in the groove between the plate of the ethmoid and the nasal bones. The wrapping of gauze should be held in position by the porte-mèche, the fingers, or the forceps while the smooth rod upon which it has been carried into place is withdrawn.

If the comminution and displacement have been marked, a small cylinder of gauze should be put into each nostril. This plug, if well placed, certainly helps to maintain the fragments in good position and does not interfere with respiration. It helps to prevent contamination of the wound by the secretions of the nose, and it is a most efficient treatment for the free hemorrhage which occasionally occurs. The plugs of gauze should be allowed to remain undisturbed three or four days,

and then may be renewed if deemed necessary. As the adjustment of the displaced fragments is painful, anæsthesia may be necessary, and should be used rather than accept an imperfect adjustment as final. If the fracture is at the cartilaginous junction, the plug of gauze must be made large enough and firm enough to give distinct support to the misplaced cartilage or the deformity is almost sure to recur.

It has been recommended that the nose be transfixed with a needle and the ends of the needle supported by pads. This might give efficient support under some circumstances, but it is rarely necessary. External supports are of little avail, and the strips of plaster used for this purpose are of little use except to protect the external wound and to conceal deformity. Cotton steeped in comp. tinct. of benzoin and coated with collodion makes an efficient protective dressing. The bones are vascular, well nourished, and consolidate rapidly, being fairly firm in ten days or two weeks. Rubbing the nose, blowing, or sneezing, however, may displace the fractured bones during the first ten days.

Lachrymal Bone.

The lachrymal bone is broken in fractures of the base of the nose. It accompanies fractures of the nasal process of the superior maxilla and the lateral plate of the ethmoid. Emphysema is frequently present. The lachrymal duct may be obstructed.

The TREATMENT of fractures of the lachrymal bone is the treatment of the more serious injuries of which it is the accompaniment. The lachrymal duct must, however, be kept free by the passage of a full-sized probe.

Superior Maxilla.

The nasal and alveolar processes are frequently broken. The nasal process suffers fracture in the crushed injury of a broken nose. The alveolar arch is broken by blows which loosen the teeth or break away the entire arch or a segment of it. Fractures of the body of the bone are the result of great violence. The blow may be transmitted through the malar bone. The injury inflicted in this way is to the wall of the antrum. Breaks in the body of the bone may separate the alveolar arch and the palate process from the upper segment of the bone.

This complete and extensive fracture is usually accompanied by a fracture of the palate bone, and may involve the pterygoid process of the sphenoid bone. The separation may be complete and the movements of the detached lower segment quite free. Comminution of the bones of the face results from violence inflicted by a blow from a club, a kick of a horse, or, as in one case that came under personal observation, by the hoof of an ox which was planted on the face of a prostrate man. Undue mobility, irregularities in the outline of the face, hemorrhages from the nose, the mouth, the pharynx, or the orbit, as also emphysema, crepitus, and the history, indicate the character of the injury. Stimson states that Guérin has found mobility and crepitus of the pterygoid process characteristic of the horizontal fractures of the bone where the symptoms were obscure.

Patients bear these injuries wonderfully well. Repair is rapid and union by bone almost certain, though the deformity may be great. It is earnestly recommended that all fragments shall be left in place, as no portion of the bone, unless it be completely detached, should be removed. All the fragments should be saved and moulded into the best possible shape, and then given such support as it is possible to secure to keep them in place. Loose teeth should not be removed, for they will become fixed in position again. Notwithstanding the extreme vascularity of the parts, hemorrhage is not apt to be excessive. The

cavities of the nose, the pharynx, and the mouth, as also wounds of the skin, are open avenues to infection. Phlebitis, lymphangitis, septicæmia, erysipelas, and necrosis are possible complications which make the injury a serious one. Suppurative inflammation of the antrum is also a troublesome sequel which may develop.

Partial fractures of the alveolar arch must be held in place, if mobility or displacement be present, by wiring the teeth in the fragment to the adjacent teeth in the uninjured portions of the arch. The fragment of the arch, either with or without the teeth, may be secured by an interdental splint of wire, gutta-percha, or other suitable material. The skill of the dentist is often required. Displacements of portions of the body of the bone are often difficult to treat. The displacement is generally downward and backward. The fingers in the mouth and a blunt hook to catch behind the palate or to hook over the orbital margin, or to pass from a wound or incision in the cheek about some point of the displaced bone, even when vigorously used, cannot always accomplish perfect adjustment. This is especially true in fracture of the maxilla with depression of the malar bone.

Consolidation is rapid, repair being complete in a few weeks. Suppuration and necrosis may delay repair and make the union of the fragments tedious. Fortunately, the violence usually forces the fragment downward; hence it is only where the base of the nose is injured that we are liable to direct injury to the base of the skull and brain as a complication in the fracture of the superior maxilla.

Malar Bone and Zygomatic Arch.

The body of the malar bone is very rarely broken, for it is thick and strong and articulates with a bone which gives way and allows displacement inward before sufficient force has been applied to cause fracture. The wall of the antrum caves in or the bone is displaced toward the orbit. The zygomatic arch breaks under direct violence or as a complication in the displacement of the malar bone. The break most frequently occurs in the temporal portion of the arch.

Deformity, pain, and interference with the motion of the lower jaw are the SYMPTOMS most frequently present. The depression at the seat of the fracture is not so difficult to correct as it is where the malar bone is displaced and the fracture of the arch occurs as a complication of fracture of the maxilla.

The zygomatic arch may be elevated and the malar bone occasionally brought into position by passing a hook under the zygomatic process of the malar bone and pulling and lifting it into place. The incision through which the hook is passed need not make the fracture a compound one, and is not a dangerous proceeding if made with aseptic precautions. If the injury is confined to the arch, the normal outline can usually be restored, but if the malar bone is fractured and displaced, even great force will not always correct the deformity.

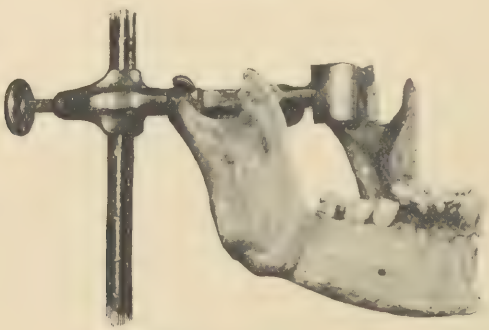
Inferior Maxilla.

The position and prominence of the inferior maxilla greatly expose it to fracture. It is a dense, strong bony arch, compactly formed, somewhat elastic, capable of free lateral movements, and well calculated to resist violence and maintain its integrity. It is, however, more frequently broken than any of the bones of the face. Fractures occur

most frequently in the body of the bone. Compression at the angles or blows upon the angle may break it near the centre of the arch, but the symphysis and the anterior portion of the body are the parts most exposed to direct violence, and are thus frequently broken. The ramus and the coronoid processes, though protected from violence, are generally broken by the direct injury of blows or by penetrating wounds. The condyle—or, more correctly, the neck—is broken by indirect violence transmitted through the body of the bone from the chin. The site of the most frequent fractures is at or forward of the mental foramen, often at the symphysis.

The fracture is most frequently slightly oblique, extending downward and backward, and it is bevelled so that the anterior fragment is longer on its internal surface (Fig. 303). Fractures may occur at every part of the body of the bone.

FIG. 303.



Fracture of the lower jaw.

When they occur at the angle the obliquity is apt to be more marked. The bone is not infrequently, perhaps in one-fourth of the cases, broken at two separate points. The multiple associated fractures are situated, usually, one in the anterior portion of the bone, and the other at or near the angle of the opposite side, but the seat of the multiple fractures may vary from the condyle to the symphysis. Nearly all of the fractures are compound by communication with the oral cavity. This is especially apt to be the case where a tooth has been displaced.

DIAGNOSIS.—The diagnosis is easily made except when the fracture is in the coronoid process or in the ramus of the jaw. It is sometimes extremely difficult to determine the presence of a fracture when it is distinctly above the angle of the ramus.

The general SYMPTOMS of a fracture of the jaw are pain, deformity, mobility, and crepitus. The pain is provoked by the movement of eating and talking, and is often very great. The patient endeavors to mitigate its severity by supporting the jaw. It should be remembered that the *inferior dental nerve* passes through the body of the bone. This nerve may be torn, but if not torn its encasement in a broken bony canal no doubt adds to the severity of the pain on any motion of the fragments. Fractures anterior to the mental foramen should not be so painful as those situated farther back in the body of the bone. The deformity is best recognized by observing irregularities in the teeth. The fracture rarely occurs in the body back of the molar teeth. The anterior fragment is apt to be displaced downward and inward. Where

the fracture is well back toward the angle or in the ramus or neck, the deformity can sometimes be best detected by observing the symphysis. If this be displaced to one side of the central line of the upper incisors, and there be tenderness and pain in the region of the ramus on the same side, it is suggestive of fracture, and careful search should be made for it. Mobility may be very free, but slight mobility is most common. Mobility, when the fracture is in the neck or condyle, may be appreciated best during movements of the jaw. Crepitus is usually plain and easily detected, except in fractures of the coronoid process.

One or more teeth are loosened in fractures through the alveolar arch. Sometimes a section of the alveolar arch with several teeth is broken from the body of the bone. The vascular supply is, however, good, and with the union of the fragments the teeth become firm again. Loose teeth should not be removed until it is evident that they will not become fixed in position. Necrosis of small fragments is frequent after these fractures. It is not, however, serious, except as it provokes suppuration and delays union.

The TREATMENT required in the great majority of cases is simple. It is not easy to secure immobility, but the slight movement between the fragments does not appear to interfere with union. Many of these fractures recover with practically very little help from treatment. To secure as much stability as possible the body of the jaw should be supported by a splint or bandage and held against the upper jaw, which

FIG. 304.

Application of four-tailed bandage.

serves as a splint. A moulded pasteboard, felt, or gutta-percha cup makes a good splint. This should be fitted to the chin and the body of the jaw, and serve as a cup in which the jaw rests, a padding of common non-absorbent cotton being placed next to the skin. This splint is held in position by a four-tailed bandage. The sling or four-tailed bandage may be used without the splint (Fig. 304).

Putting a *wire* or *silk ligature* about the teeth in many of the fractures is a simple and an efficient treatment if used in conjunction with an immobilizing cup. The wire loop should include at least two teeth on each side of the break, as constant tension on the teeth will soon loosen them. The wire should be silver, of medium size, and not too tightly drawn. If only the teeth next to the break are surrounded by the wire loop, their loosening is very apt to increase the irritation

about the fracture. If the break is markedly oblique, the difficulty in adjusting the fracture is often very great, and the retention in good position by a supporting splint is unsatisfactory. In these cases the tension on the wire loop is too great for the teeth to bear, and the tendency to displacement is so great that it will frequently break a wire if it is passed through drill holes in the bone. Interdental splints of heavy wire fitted to the teeth, formed from a plaster mould, are at times very valuable. The fastening together of the lower and upper jaw by wire loops about the teeth may offer material help during the short time it is necessary to immobilize the fracture.

Ivory pegs driven through drill holes made in the bone near the break are usually efficient and satisfactory. Generally a drill hole in one end may be so placed that the peg can be passed through it and forced into the cancellated tissue of the other end in a way to immobilize the fracture. If the bone be kept quiet for a week or ten days, it is not difficult to maintain reduction during the time necessary for consolidation. The ivory peg or the wire loosens in the bone by the rather rapid absorption, and the support given becomes lax. The ingenuity of the surgeon will often be taxed to the utmost to devise methods to immobilize some of the fractures of the jaw.

Union is rapid when necrosis does not occur. The bone is fairly firm in three weeks, though mastication of solid food should be longer delayed. Non-union is very rare. Fractures through the ramus of the jaw do not show much displacement. Immobilization of the jaw is all that is required in the way of treatment.

The Hyoid Bone.

The **hyoid bone** is broken by compression, either by direct force or by bending the head forcibly backward. Hemorrhage or marked inflammation, with collateral œdema, may render the injury serious. The swelling may impede respiration. The fracture ordinarily unites readily and without much inflammation, the union being either cartilaginous or bony. The result is usually satisfactory, as the displacement is generally slight. Dyspnœa, difficult deglutition, and pain on talking may be present as symptoms.

The TREATMENT is symptomatic. If the displacement is great, or if the cornua has penetrated the pharynx or been turned so as to be caught in the tissues, an attempt should be made to replace the fragment, and if this should be impossible it may be removed. The œdema of the glottis may demand tracheotomy, and the difficulty in swallowing might necessitate feeding by an œsophageal tube.

The Ribs.

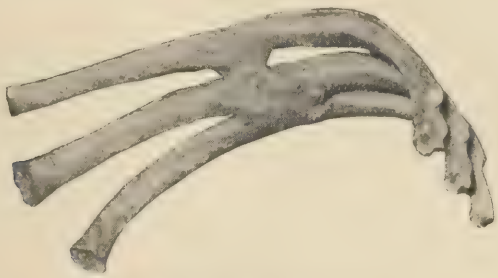
Fractures of the ribs are frequent, but authorities differ as to the most common seat of these fractures. They are broken generally in the lateral wall of the chest (Fig. 305) at or between the angle and the anterior third of the rib. It is a very rare accident in the child, frequent in the adult and aged. It occurs from direct or indirect violence. It may result from a compressing force, one or more of the ribs being broken.

The displacement is slight when only one rib is broken, but may be very considerable where several are broken. Direct violence produces fracture by pushing the arch of the rib inward, while indirect violence increases the outward curve until the bone breaks. The ribs most frequently broken are from the fourth to the eighth inclusive. The first, second, and third are well protected from violence by the clavicle, by the pectoral muscles, and by the shoulder. The lower ribs are

not fixed and elude violence, so that they are rarely broken. The fracture is not often compound, except in those cases produced by direct violence. Penetrating wounds producing fracture may also add to this complication a wound of the pleura, the lung, the diaphragm, or the pericardium. Hemorrhage into the pleural cavity is at times a dangerous complication.

Symptoms.—Collapse or profound depression may follow the violence inflicted. A weak and rapid pulse with dyspnœa and local pain are present in the graver injuries. Pain which is made worse by pressure at the point of fracture, or by pressure which will increase the arch of the rib, is an important symptom. *Diaphragmatic* or abdominal *respiration* is present. *Emphysema* beginning at the seat of the fracture may extend over the body. Hemorrhage from the wound, if the fracture is

Fig. 305.



Fracture of ribs; synostosis.

compound, may be either external or into the thorax. *Hæmoptysis* from the wounded lung may occur. Crepitus may be distinct, but is often absent. The displacement is rarely enough to require attention except when several ribs are broken. It may then be necessary to correct the deformity by adjusting the fractures and securing them in position by fastening the ends together.

Treatment is directed to the relief of pain, to limiting the motion of the chest-wall in breathing, to the arrest of the hemorrhage, and to the control of the irritation of the injured parts. Pain is relieved or controlled by a firm bandage or plaster strip applied so as to encircle the thorax and limit the movement of the chest-wall in respiratory efforts. This firm bandage helps to immobilize the fragments. Anodynes are also most useful, and in many cases must be resorted to. Relief from pain favors reaction and shortens the depression following the injury.

Hemorrhage from an external wound may be controlled by direct ligature or by pressure. A pouch of gauze may be carried through the bleeding wound into the cavity of the thorax and stuffed with small strips of gauze, so that a knob of gauze can be firmly pulled against the inner thoracic wall. This prevents hemorrhage into the thorax, and by its pressure arrests it in the intercostal space. Hæmoptysis is not often very free. Hemorrhage must always be carefully considered and controlled.

The Sternum.

The **sternum** is an open cancellated bone composed of several pieces which unite at different periods of life. It may be broken or separated

at the junction of the manubrium and the body, or the break may occur at the cartilaginous junction of the separate pieces of the body of the bone. According to Hoffa, statistics show that the sternum is broken less often than any of the bones, making only about 1 per cent. of fractures. The sternum is fractured most frequently by forcible flexion of the spine. A fracture induced in this way is most apt to occur in the upper section of the bone. Muscular action must also be recognized as a source of fracture. The great muscular effort used in lifting heavy weights has produced this fracture. Blows upon the sternum by a pole or club may induce fracture by direct violence. By far the larger number of fractures result from the forcible bending of the body, either from a fall upon the head or the buttock, or by being caught while in a sitting posture between a moving wagon or car and a beam overhead, and thus forcibly bending the spine.

The displacement at the seat of fracture may be marked. It is most frequently a forward displacement of the lower fragment, though it may be the reverse. This can be reduced usually by throwing the shoulders and head backward and taking a deep inspiration, though direct pressure upon the overriding end may aid in reduction. It is not always easy to maintain reduction. A pad over the fracture with a circular bandage pinned snugly around the chest may assist materially, however, in maintaining it. The union of the fragments is usually rapid, and even if the displacement is not corrected, the function of the bone is restored. If the displacement is a source of great discomfort and danger to the patient, it should be corrected, even if an incision is necessary, and ivory pegs or steel nails may be utilized to secure the reduction.

The *xiphoid cartilage* may be luxated or broken. This is sometimes a painful and dangerous accident, as it may induce spasm or irregular action of the diaphragm and violent vomiting. If its symptoms should be violent and serious, it can be exposed and fastened into place or removed.

The Clavicle.

The clavicle is exposed to both direct and indirect violence. It is a curved slender bone, and to it or through it is transmitted the force of falls upon the hand, the elbow, and the shoulder. Direct blows upon the upper surface of the shoulder or upon the anterior surface of the base of the neck are also received by the clavicle. It is a very common break, constituting 15–16 per cent. of all fractures. It occurs most frequently in children under five years of age. It is comparatively rare in the aged, but frequent in middle life. The common seat of fracture is in the body of the bone just outside the middle, near the junction of the external with the middle third. The fracture at this site is generally the result of indirect violence. It is produced by a blow or a fall upon the shoulder or by violence transmitted through the arm. Any portion of the bone may be fractured by direct violence, though the external end is rarely the seat of fracture. It is rarely a compound fracture, although the bone is superficial, being covered only by the skin and subcutaneous tissue. Complications in the way of damage to adjacent important structures are also rare, the subclavian vessels, the plexus of nerves, and the pleura almost uniformly escaping injury.

The *displacement* in fracture of the clavicle is very uniform—viz. the internal fragment is pulled upward by the sterno-mastoid, and the external one depressed

and carried inward by the weight of the shoulder and by muscular action. Displacement of the fractured ends is less marked if the seat of fracture be near either end.

The SIGNS AND SYMPTOMS OF A FRACTURED CLAVICLE vary with the seat of fracture. The deformity and disability are less marked when the break is in the outer third. If it be in the body of the bone, the shoulder drops downward, and if the displacement be marked, it comes forward and inward. The head is turned toward the affected side and the patient seeks to support his forearm and elbow. The irregularity at the seat of fracture is easily discerned. The pain on motion is acute and the loss of power in the arm is complete. These signs are nearly all well marked in the adult, but in *children* a break in the clavicle often occurs with little displacement. The periosteum may remain untorn and the ends of the bone remain in good position. This modifies the deformity and lessens the pain, and the loss of function is not so complete, so that it is not an infrequent thing to have the injury overlooked by the mother for several days.

TREATMENT.—Cases of the character last mentioned need but little treatment. A well-adjusted sling, giving support to the forearm and the elbow and confining the hand and arm of the child, will often answer all the indications. Strenuous but injudicious efforts to immo-

FIG. 306.

Moore's dressing for fracture of the clavicle.

bilize the shoulder in these simple cases may provoke further displacement and add to the deformity and pain. The multiplicity of the plans suggested for the treatment of fractures of the clavicle testifies to the inadequacy of the methods in vogue. The results of treatment in cases in which the deformity is marked are usually not perfect. There is generally a little shortening and a well-marked callus. A comfortable and fairly-efficient method of treatment is the "double figure of 8" sug-

gested by Dr. E. M. Moore of Rochester, New York (Fig. 306). The illustration shows the bandage applied. It is as follows: A strip of muslin a little over two yards in length and wide enough to be folded four times upon itself until it is a strip eight inches wide is held on the surgeon's hand; the hand is placed under the elbow of the injured side; the folded strip with ends of unequal length crosses the under surface of the flexed forearm at the elbow. The longer end, which is to the inner side, is passed upward inside and in front of the arm and is carried over the shoulder across the back and through the opposite axilla. It is brought over in front of the sound shoulder and meets in the back the short end, which is carried first up over the outside of the forearm and backward across the spine.

These ends are secured to each other in the back and about the sound shoulder. The hand is supported in a sling which is attached to the bandage as it passes over the injured shoulder. The efficiency of Moore's dressing depends on a recognition of the position of the fibres of the pectoralis major. Those arising highest are inserted lowest on the humerus, the tendon making a half turn as it descends to its insertion. Hence the farther back the elbow is held, the more are the clavicular fibres pulled upon—*i. e.* the fragments held in place.

The figure of 8 crossing over the spine with a loop around each shoulder is frequently used. The loop placed about the injured shoulder should fit rather snugly, so that it will not slip too far inward from the point of the shoulder. If the loop is too large, it makes a downward pressure on the outer fragment, and tends in that way to increase the deformity. The most efficient treatment is attained by placing the patient in the recumbent position on his back, with a firm support under the spine. This should be so adjusted that the injured shoulder is allowed to hang free, its weight carrying it upward and backward. This treatment enforced for three weeks gives very good results. It is simple and effective, but irksome, and very few patients will submit to the position and the long restraint.

THE SCAPULA.

The **acromial process** of the scapula is usually broken by direct violence. The break is most often near the end of the process. The mobility of the fragment is easily detected, so that the diagnosis is not difficult. The outline of the spine can be followed, for it is subcutaneous throughout the entire length. The pain and contusion confirm the diagnosis. The union is usually ligamentous, rarely bony.

The TREATMENT consists in holding the head of the humerus well up in the glenoid fossa and immobilizing the arm. This is most comfortably accomplished by a broad strip of folded domestic, which is so placed that its central portion passes under the elbow. The ends of the strip are carried upward to the shoulder and crossed over it, and carried across the chest in front and behind to the opposite axilla, and secured to each other as they meet. The hand should be secured in a sling fastened to this bandage at the crossing above the shoulder. A pad of cotton or wool should be put in the axilla, thick enough to keep the arm from the body, so that the humerus may be nearly vertical.

The next most common fracture of the scapula is of the **surgical neck.** In this fracture the break passes from a point below the glenoid fossa upward to the suprascapular notch, including the coracoid process.

The SYMPTOMS are lengthening of the arm, flattening of the shoulder, an unoccupied space below the acromion, loss of function of the arm, crepitus, and an easy reduction, with immediate recurrence of the deformity as soon as the support under the elbow is removed. There is unusual passive mobility of the arm in this fracture. The union is usually bony and occurs promptly with restoration of the function of the arm.

The TREATMENT enforced should support the arm firmly, so that the head of the humerus is pushed up against the acromion process. The head of the bone and the neck of the scapula should be held out from the body by a pad. This may be accomplished by the support given to the elbow by a broad strip of adhesive plaster (moleskin), which should pass about the body and up over the top of the sound shoulder. It should be firmly applied. The arm is thus immobilized after carrying the elbow forward on the chest.

The **angles** of the scapula, and also the **spine** and the **body** of the bone, are broken by severe direct violence. There is not much displacement except where the fracture involves the inferior angle, which may be carried forward and upward. The fragments can generally be moved, so that crepitus is evident. The bone is well protected with muscles, and it is not easy to detect irregularities of outline.

The TREATMENT consists in padding the scapular region and binding it firmly to the chest-wall. The arm must be immobilized by fixing it in a sling.

The Humerus.

The **humerus** is not broken as often as the clavicle or the bones of the forearm. The fractures of this bone are to be considered in groups—first, of the upper end; second, of the shaft; and third, of the lower end. Fractures of the **anatomical neck**, fractures through the **head** or through the **tuberosities** and the **head**, may well constitute one class of the first group, as the clinical history is much the same. A fracture of the *anatomical neck* is very rare. The line of the break generally follows the groove between the tuberosities and the smooth cartilaginous head. Fractures through the *head* rarely occur, except as a complication of the more extensive fractures through the tuberosities and the surgical neck. Fracture through the *tuberosities* does not occur frequently. These breaks are generally produced by direct violence, rarely from uncomplicated indirect violence.

Fig. 307.

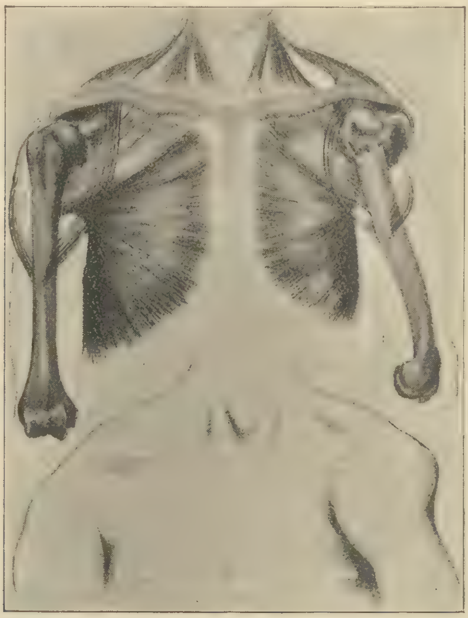
Fracture of the anatomical neck of the humerus (Hoffa).

The SYMPTOMS accompanying these fractures are not so distinctive as to permit a differential diagnosis. The shoulder is swollen and generally flattened over the joint. Crepitus is present and the function is lost, while pain is quite marked, especially on motion.

The tearing or breaking off of the greater tuberosity occasionally occurs as a complication of subcoracoid dislocation of the humerus. The line of fracture usually involves the bicipital groove, the shaft and head of the bone remaining intact. The loss of power of external rotation is evidence of this fracture. It appears to me very probable that this fracture—viz. the one which separates the greater tuberosity from the head by running along the anatomical neck and thence into the bicipital groove—may continue inward under the lesser tubercle and separate the head and the lesser tubercle from the shaft. Such a fracture has been described by Robert Smith.

Fracture of the **surgical neck** is the most frequent and the most important of this group of injuries. The line of fracture is below the tuberosities and above the insertion of the pectoralis major and the

FIG. 308.



Fracture of the surgical neck of humerus (Hoffa).

latissimus dorsi (Fig. 308). It results from either direct or indirect violence.

This fracture usually presents a well-defined group of SYMPTOMS. The head of the bone can be felt in its proper place. The axis of the shaft points inward toward the coracoid; the upper end is almost always pulled inward by the pectoral muscle and by the latissimus dorsi. It makes a slight angle with the head; crepitus is distinct, and can be elicited by traction and rotation; the arm is shortened and hangs powerless at the side; and mobility is marked. The head of the bone is in the proper position, but does not rotate with the shaft; voluntary movements are lost, while passive movements are free. Fractures at the upper extremity of the bone may be impacted, and are then rendered still more obscure. The violence producing this fracture is well calculated to produce separation of the epiphysis in young subjects. The displacement is, however, different.

The deformity resulting from **epiphyseal separation** has its angle outward and forward instead of inward and backward. The lower fragment is prominent and stands forward. The axis of the humerus is directed upward and forward. The break following the cartilaginous line leaves an abrupt right-angled surface which marks the anterior margin of the shaft and can be outlined, as it pushes forward the skin. This displacement is the usual one, and is best reduced by carrying the elbow upward and forward while making traction upon it. The motion of the head is arrested when the inferior posterior portion of the capsule is put upon the stretch, and by pressure and manipulation the displacement, though difficult to reduce, can usually be overcome. This epiphyseal separation cannot, of course, occur after union of the shaft and the epiphysis in or about the twentieth year.

After the reduction of the displacement present in this group of injuries the TREATMENT which is adapted to the most common fracture—viz. that of the surgical neck—answers the indications that should be met in the others. The deformity present in the fracture of the surgical neck may be corrected by traction downward, outward, and forward until the shaft comes into line with the head. Direct pressure of the hand aids the movement of coaptation. If the patient is able to sit up, the dressing is more easily applied. The elbow should be held just away from the body and the forearm flexed at right angles. The splint most universally applicable for these fractures is the plaster-of-Paris folded compress or a plaster roller. It should extend from the lower part of the forearm to the top of the shoulder, enveloping both the elbow- and the shoulder-joint. The entire arm should be first wrapped in cotton. During the application of the plaster splint extension from the elbow is continued.

A piece of pasteboard, not too heavy, may be carried into the axilla, outside of and overlapped above by the cotton which is next to the skin. The arm must be held in about the position it is desired to retain while the plaster cup is being adjusted to the shoulder, for if it is held in a position of too great abduction, the cup will not fit the shoulder when the arm hangs at the side. Pasteboard splints or starch bandages may be used instead of the plaster-of-Paris bandage, but care must be taken to see that the supporting splint is not too tight. The splint to secure immobility must envelop the elbow-joint, the forearm, and the shoulder. The weight of the arm and the splint are the chief agents in maintaining a proper adjustment, it being impossible to fix the upper fragment by any direct pressure. The forearm must be supported by a sling which is placed about the wrist. The sling must not give support to the elbow. It does not appear to me to be good practice to bind the arm to the body in any of the fractures of the humerus, for the movement of the body in flexion or lateral motion must disturb the arm.

If these fractures be *complicated by dislocation* of the head of the humerus, they are of much more serious import. Reduction of the dislocation must at once be attempted by manipulation. If this fails, then either at the first dressing or at some time within a week or ten days, as indications may suggest, the reduction must again be attempted by cutting down upon the fracture and attempting reduction by McBurney's method—that is, with a hook passed into a hole drilled into the upper fragment. Traction and rotation through the medium of the hook, together with a more direct manipulation of the parts, should succeed in effecting a reduction of the dislocation. Reduction may possibly be accomplished by direct manipulation of the head without the hook. After the reduction of the dislocation the treatment is to be directed to the cure of the fracture. If the local condition be such as not to permit the application of a splint, the patient should be placed upon his

bed, and, while the arm is placed in a comfortable position on pillows, traction should be made by means of adhesive strips and weights and pulleys or by elastic bands until the swelling subsides.

Two points must be clear to the surgeon in treating injuries of the upper end of the humerus. These are usually easily determined, as they present distinctive diagnostic symptoms. The most important point is to know that the *head is not dislocated;* second, that the injury is *not confounded with fracture of the neck of the scapula.*

The **shaft** of the bone is frequently broken by direct and indirect violence, but muscular action is not an infrequent source of fracture. Displacements in the broken shaft may be lateral, angular, rotary, or overlapping. Mobility is marked; crepitus is easily obtained; shortening is not usually very marked; swelling and pain are present. Injury to the musculo-spiral nerve is one of the complications of this fracture, as is also injury of the brachial artery. The nerves may be injured by the violence of the accident or by involvement in the callus. Injury to the artery may be detected by a disturbance of the circulation and absence of the radial pulse. Motor and sensory disturbances indicate the extent of the nerve-injury. Plate XXI.

Delayed union and non-union are said to be more frequent than in any other bone, but the fracture is easily managed and is almost uniformly satisfactory in result. If the circulation is free, the nutrition should be good and union fairly certain. This bone has, however, been known to disappear by absorption after fracture. Untoward results of this kind cannot be guarded against, so that, though it is an injury which usually results in union, it may be accompanied by grave complications. These fractures should be treated as are those of the upper end of the bone. The splint should immobilize the shoulder and the elbow, while it gives some lateral support to the break. A plaster-of-Paris or starch bandage or pasteboard splint should be used.

Fractures of the **lower end of the humerus** are frequent, and are of the greatest importance, for imperfect adjustment is likely to result in permanent deformity and impairment of function. It is always desirable to make an accurate and exact diagnosis, though it is sometimes difficult or impossible to do so.

The **epicondyles** are subject to fracture by direct violence. The line of fracture does not usually enter the joint. The internal epicondyle is the much more prominent and is most frequently broken. The fracture does not involve the joint, and the displacement is not usually great. The intermuscular fascia helps to retain these fragments in position, though they are occasionally torn loose from their muscular attachment. When this occurs they may be distinctly separated from their normal situation. If detached and in bad position, it is well to remove the fragments.

The TREATMENT is rest with the forearm fixed in a flexed position.

Supracondyloid fracture and **separation of the epiphysis** are similar in some of their symptoms, their correction, and their treatment. They both ordinarily result from indirect violence. The epiphyseal separation follows the line of the cartilage, and is nearer the articulation than the supracondyloid fracture. The position of the arm in each of these injuries is much the same, the arm being slightly flexed, with

PLATE XXI.

Supra-Condyloid Fracture, child of nine years; union with deformity, fragment so joined to lower end of shaft of humerus at an angle that when forearm is completely flexed upon this fragment, it yet is only at right-angle with arm. Operation indicated. (X-Ray picture.)

marked fulness in front of the elbow, and the olecranon more prominent posteriorly. The deformity is increased by putting the arm in an extended position, and is diminished by flexion. Mobility is increased, the crepitus is soft in epiphyseal separation, and is easily elicited in supracondyloid fractures. The projection in front of the elbow-joint is sharp and more easily outlined in the fracture than it is in the epiphyseal separation. Here, as in all injuries about the elbow-joint, it is important to determine the relation of the olecranon to the external and the internal epicondyles. They maintain their normal position in both of these injuries. If the arm be flexed, a line drawn from one epicondyle to the other in a vertical plane crosses the top of the olecranon. If the arm be extended, a line so drawn in a horizontal plane also touches the top of the olecranon. In a dislocation of both bones of the forearm backward, which simulates these injuries, this relation is altered.

Either **condyle** may be broken from its fellow and from the shaft of the bone. A transverse supracondyloid fracture may be complicated by a fracture extending from the transverse line of fracture to the joint (Fig. 309). These fractures implicate the joint. They may result from direct or indirect violence. The fracture may be comminuted and compound, and the contusion and the laceration are often extensive. The T-fracture above described is the intercondyloid fracture and is usually produced by direct violence. The separation of either condyle is more frequent than the intercondyloid fracture. The lines of separation in these injuries vary considerably, but the treatment is much the same.

Fig. 309.

T-fracture of humerus (Helferich).

In fracture of the **external condyle** the fragment is more apt to be displaced forward. Fracture of the **internal** may be associated with a backward displacement of the bones of the forearm and with widening of the joint. In these fractures swelling, ecchymosis, marked mobility, and crepitus are present. The deformity may be marked in any of these injuries, but it is always great in the intercondyloid.

The surgeon must bear in mind that a good movable joint is to be sought in these fractures, and it is usually attained if the treatment is directed by tact and good judgment. It must not be conceded that fracture into the joint necessarily implies a bad result. The extent of the injury, the comminution of the bone, and the violence of the separative action, may result in a stiff and deformed joint, but this is not the usual result. Accurate adjustment is the essential to successful treatment. Maintenance in perfect position is not always possible, but may be attained in the majority of cases. An anæsthetic is here not infrequently demanded in order to make an accurate diagnosis and to secure good adjustment. The surgeon must bear in mind the fact that the axis of the forearm and the arm are not the same when in a position of extension. They make an obtuse angle, the forearm diverging outward, so that when hanging at the side, in a position of supination, the hand is carried away from the body. It is also extremely important, both on

account of symmetry and usefulness, to retain this outward deviation, which gives to the arm its carrying power. How may accurate adjustment and maintenance be best attained? The fragments can be most accurately moulded into position when the arm is extended or when only slightly flexed. The extended position is often necessary to perfect adjustment. If a splint is to be adjusted to the arm, and it is not thought best to flex it to a right angle, it should not be placed in full extension, but slightly flexed. The support may be a posterior splint or an immovable cast. Elastic extension or traction by pulley and weight is occasionally necessary if the swelling be too intense to permit the immediate application of a retaining splint.

It has been a habit with me to treat these cases in a right-angled splint. Good results have been the rule, but in the condyloid fractures the position of very slight flexion is the best for accurate adjustment, and the arm may be secured in this position. It is, in my opinion, important that the recumbent position be assumed for a time in the cases dressed in full extension. I have in a number of cases, after using this position for a week, flexed the arm to a right angle and then continued treatment in a rectangular splint. Passive motion in order to retain mobility of the joint is out of place and *dangerous.* It is to be condemned as pernicious. The joint is to be put at rest until the bone is consolidated; then the patient will gradually recover motion if the adjustment has been good.

The splints most useful in these fractures are those which can be moulded to the outline of the parts. Plaster of Paris, pasteboard, and starch are the most useful. If it be desired to inspect the arm, a section of the cast may be cut away. The cast can then be replaced and held in position by a roller bandage. It requires five or six weeks to secure good union in fractures of the humerus. There is but little danger of permanent loss of motion in the joint if the adjustment has been perfect, though every surgeon will meet cases in which even with the greatest care a deformity will occur that impairs the symmetry of the arm or the function of the joint.

Fractures of the Forearm.—The Ulna.

Fractures here, excepting Colles' fracture, most frequently involve both bones, but either bone may be broken without implicating the other.

Muscular action sometimes produces fracture of the olecranon process, the fragment so detached being usually a thin portion, often only a scale from the tip. The process is more frequently broken by direct violence, which usually occurs in a fall with the elbow bent and striking against a hard substance. The process is thus broken off near its junction with the shaft. In these cases the muscular contraction of the triceps materially aids the violence in producing the fracture. The joint is opened, and, the bone being so superficial, the fracture is easily rendered compound by the violence producing it. The contusion inflicted and the involvement of the joint result in rapid swelling. The tumefaction of the parts obscures the injury somewhat, but the diagnosis is not usually difficult, for the posterior surface of the process is subcutaneous and the line of fracture can be felt on the sharp ridge which is

continuous with the shaft of the bone. If the laceration is extensive, the detached fragment may be pulled well up by the triceps. In these fractures the tip of the process does not hold its proper relation with the epicondyles, and this relation is especially destroyed when the arm is flexed at a right angle.

It is not always feasible to put the part in good position at the first dressing. It is well to put a splint on the arm while it is in a position of slight flexion, though later in many cases the arm may be safely flexed to a right angle. A plaster-of-Paris case makes a good splint for immobilizing the arm. After it hardens a large fenestrum can be cut in it, so as to expose the posterior surface of the joint. Then a compress can be placed above the olecranon process, and be made to pull it downward toward the ulna by a strip of adhesive plaster or an elastic band

Fig. 310.

Fracture of olecranon with fibrous union (Park).

that should be secured to the anterior surface of the plaster splint some distance below the bend of the elbow. After a week or ten days the splint can be changed to a right-angled plaster cast and the same method of pressure continued. It is well to have firm pressure made over the subcutaneous surface of the process at the time of the bending to avoid a tilting or angling of the fragments. The result is usually good, a close fibrous or bony union being attained. Passive motion is to be avoided until the fragment has firmly united.

The **coronoid process** is rarely broken, except in the backward dislocation of both bones by the combined force of the muscular action of the brachialis anticus and the pressure of the coronoid against the trochlear surface of the humerus. It must be a rare injury even under these circumstances, for a backward dislocation occurs most frequently from hyperextension of the arm. It should be treated by putting the arm at rest in the right-angled position.

The **shaft** of the bone is broken singly almost always by direct violence. Breaks are more common in the lower half of the shaft than in the upper part.

The DIAGNOSIS is easy: crepitus, irregularity in outline, generally due to the violence producing the fracture, pain at the seat of fracture, swelling, and loss of power, with the history of the accident, make the evidence of fracture conclusive.

TREATMENT.—The arm should be placed in a semi-prone position, and an anterior or palmar splint extending from the internal epicondyle to the fingers, and a posterior dorsal splint that should extend from the metacarpus to the head of the radius, should be used. These light wooden splints should be padded with cotton and should be a little wider than the forearm. A pad should also be placed against the ulna at the

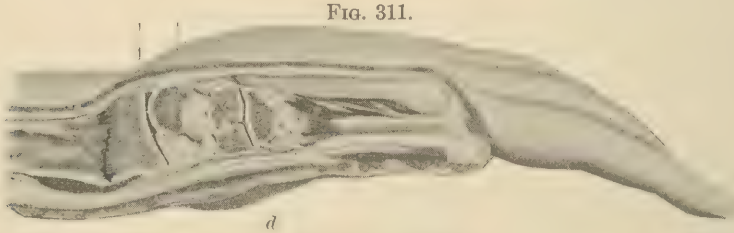
fractured point, if this be in the middle third of the bone, so as to keep it from sagging or angling. The splints are secured in position by a roller bandage. There is not much danger of loss of rotation by angling of the bone outward toward the radius in simple fracture of the ulna. The pronator quadratus, however, tends to pull the lower fragment outward toward the radius if the break be just above its attachment to the ulna.

The Radius.

This bone is more subject to fracture than any other except the clavicle. The **head** or the **neck** of the bone may be broken either by direct or indirect violence, though indirect violence is the most frequent source of the injury. Falls upon the pronated hand drive the radius against the capitellum, thus producing these fractures. Injury to the *neck* of the radius is frequent in children. The **shaft** of the radius is broken by direct or indirect violence. Fractures of the shaft of this bone are usually complicated with a break of the ulna. The biceps, the supinator brevis, and the pronator radii teres are to be considered in treating all fractures of the shaft of the bone. If the break is above the insertion of the pronator radii teres, the upper fragment is rotated into a position of supination, while the lower fragment is in a position of pronation. The fracture is best managed if the arm is kept supine. The usual symptoms of fracture are present.

It is not easy to make the DIAGNOSIS when the fracture is in the upper part of the shaft, for it is deeply buried under the muscles. The failure of the head to rotate with the shaft of the bone in fractures of

FIG. 311.



Colles' fracture (Anger).

the neck and shaft is an important sign of fracture. It must, however, be remembered that when the fractured surfaces are interlocked the head may rotate with the shaft even if a fracture has occurred.

Fractures of the *shaft* are treated, if in the lower half, by the same method used in treatment of injuries to the shaft of the ulna. If the fracture be above the pronator radii teres, it should be treated with the forearm supinated and flexed at a right angle. A posterior rectangular splint is best. It should immobilize the elbow and secure the arm and the forearm.

The most common fracture of the radius is at the lower end, and is known as **Colles' fracture**, though the usual seat of the fracture is below the point indicated by Colles in his description. It results from a fall upon the palm of the hand, and occurs in childhood and extreme

old age, but is most frequent in elderly females. The break is rather uniform in its symptoms, position, and line of fracture. It is situated in the expanded end of the radius at from one-fourth of an inch to one inch from the articular surface (Fig. 311).

The line of fracture may be transverse or oblique, though it is difficult to determine from the many descriptions and cuts presented to the profession just what is the most common break. It appears reasonable, however, to assume from the manner of the infliction of the injury, from the plane of the articular surface, and from the uniformity of the displacement that the line of fracture is from below upward, beginning on the palmar surface and extending to the dorsum. This common fracture was for centuries regarded by surgeons as a dislocation.

The deformity resulting from the fracture is very uniform. The lower fragment is displaced backward on the dorsum of the bone, the articular end is tilted backward, and the styloid process is carried up the forearm and backward, so that, instead of being well forward and below the level of the styloid process of the ulna, it is displaced upward and the hand is drawn toward the radial side. Crepitus is not easily elicited. The deformity, the history of the accident, and the mobility of the fragments are the symptoms. Impaction of the fragments is, I believe, not very common. If there should be impaction, and it be firm enough to resist the proper adjustment, it can be released by forcibly and strongly extending the hand until the fragments separate, and then the adjustment can be accomplished in the usual manner.

The *reduction of the fracture* can usually be accomplished by the following method: An assistant holds the elbow by grasping the lower end of the humerus; a second assistant grasps the hand as if to shake hands, and makes firm extension while the hand is prone. The surgeon then places the fingers of both hands on the palmar surface of the end of the upper fragment and presses downward and forward upon the dorsal surface of the distal fragment with his thumbs. Firm pressure will almost certainly carry it well forward into position. It is rare to have much difficulty in keeping it in good position. If the fracture is not comminuted, but transverse, there is little tendency to redisplacement.

Fracture of the *styloid process* of the ulna may also occur. The obliquity of the line of fracture and the occasional comminution of the distal fragments have much to do with the difficulty in keeping the fracture in good position. Among the complications attending this fracture is a rupture of the radio-ulnar ligaments. This complication makes the prominence of the ulna more marked than the slight shortening of the radius alone could account for. The injury is, moreover, often complicated by *compound dislocation* of the styloid process, with penetration of the internal lateral ligament.

Fractures in this situation are safer and more comfortable if a splint be applied that will give rest and support to the hand and the forearm. These splints are of great variety, but the simpler ones answer every purpose. It is, I think, hard to devise one which will fulfil more of the indications than a plain straight wooden splint, properly padded, that will extend from the end of the fingers to the epicondyle. This splint should be fitted to the palmar surface, and should be so padded as to put the fingers in a position of slight flexion. Some loose cotton may be placed under the radius to support the lower end of the upper fragment. A bandage is then applied to secure the hand and forearm to the splint while it is in a semi-prone position. It is a good plan to place a compress of cotton on the dorsum of the distal fragment. At the end of a week the splint should be shortened and the fingers made

free, so that they can be flexed and extended. This is of extreme importance in patients above forty years of age. This plan of treatment secures comfortable quiet for the arm until the union is firm, and it provides for free movements of flexion and extension of the fingers after the first week. The fracture almost uniformly unites in five weeks. The sling to support the forearm should be a narrow strip, and it should exert its pressure on the forearm and not on the hand. An excellent splint is also made of lint soaked in plaster of Paris applied to the palmar surface while the parts are held in exact position.

The results should be good so far as restoration of function is concerned, and the contour is very nearly perfect, except in cases where the comminution is marked and the retention of the fragments is difficult or impossible. A slight shortening may take place in these comminuted fractures of the end of the radius.

The pistol-shaped splint and Levis's perforated moulded splint are frequently used. The deviation of the hand toward the ulnar side is not an efficient agent in maintaining the fragments in position, and should never be enforced to the discomfort of the patient. In the more common and simpler cases, where the line of

FIG. 312.

FIG. 313.

Moore's dressing for Colles' fracture of radius.

fracture is transverse or slightly oblique and not comminuted, a wide strip of adhesive plaster encircling the wrist gives sufficient support, or a firm compress made of a soft roller bandage may be fastened to the palmar side of the radius by the plaster strip to give more definite support. This treatment, devised by Dr. Moore of Rochester, is applicable to many cases and gives excellent results (Figs. 312, 313).

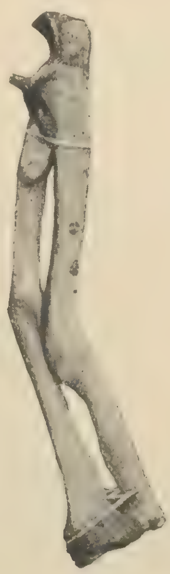
Fracture of both bones of the forearm is frequent, but it rarely occurs in the upper third. It may follow direct violence, though it is

more frequently the result of indirect violence. The displacement may be great and in any direction. Accurate adjustment is most important for overlapping; rotary or lateral displacement or any angling of either of the bones outward or inward is likely to interrupt the rotary function of the forearm (Figs. 314, 315, 316). This function is best preserved if the forearm be kept in a position of supination or in a semi-prone position, for the bones are then widely separated. In cases where there is a marked tendency to a recurrence of the displacement it is perhaps safer to keep the forearm in full supination until union is at least fairly firm, for accurate maintenance and good adjustment is best attained in this position. In a week or ten days the forearm may be put into a semi-prone position, as it is much more comfortable for the patient. The semi-prone position is the one usually preferred in these

Fig. 316.

Fig. 314.

Fig. 315.



Results attending angular fracture of the radius.

Displacement in fracture of forearm.

cases. The splints adapted to the treatment of fractures of the shaft of one or both of the bones in the semi-prone position are two straight boards of the width of the upper part of the forearm. The palmar splint should extend from the epicondyle to the ends of the fingers, and the dorsal from the head of the radius to the wrist. They should be properly padded, but interosseous pads are not necessary. A simple roller bandage answers all the purposes for holding the splints in position. The hand is fastened to the palmar splint, and the roller then envelops both palmar and dorsal splints and is continued to the elbow. The forearm is then placed in a sling and kept at rest, care being taken

to give its upper part good support. The sling should not exert traction on the hand and arm below the seat of fracture.

Green-stick fractures of the bones of the forearm are frequent. They occur in children. It is generally best to straighten the bones at the first sitting, though it is not always necessary to do so, and indeed a complete fracture may be avoided in some cases by not insisting too strongly upon a perfect straightening of the bones at once. This form of fracture usually unites rapidly. Delayed or non-union of fractures of the forearm is not uncommon. The causes which prevent primary union may render operations unavoidable. The treatment of non-union is to be guided by the general conditions which govern such cases. Injury of the blood-vessels and interference with the circulation may result in gangrene.

The Wrist and Hand.

Fractures of the carpal bones are rare, except when the wrist is crushed.

The DIAGNOSIS is difficult and replacement uncertain.

The TREATMENT consists in rest and in controlling the engorgement likely to follow such injuries.

Fractures of the **metacarpal bones** are more frequent, and may occur as a result of direct or indirect violence. The distal half of the bone is most frequently the seat of fracture. The fracture that follows indirect violence is usually situated within an inch of the articular surface of the head. The displacement is uniformly forward, with the head of the bone bent toward the palm of the hand.

The DIAGNOSIS is best made with the fingers closed, so that the first row of phalanges are at a right angle to the metacarpal bones. If the symmetry of the row of knuckles is broken by one or more of them being less prominent than they should be, it is strongly suggestive of fracture. If there be also a sensitive point on the dorsum of the shortened metacarpal, with slight irregularity at the point of tenderness, then the diagnosis is fairly certain. This may be confirmed by restoring the symmetry by traction on the finger and pushing the head of the bone toward the back of the hand.

The TREATMENT should be by traction on the extended finger with a firm pad or support under the head of the bone. The hand should be placed upon a long palmar splint securely bound to the forearm by a bandage or by plaster strips, or both. The extension should be by adhesive plaster about the finger, attached to an elastic band fastened to the end of the splint. The splint should extend several inches beyond the fingers. Union always occurs, generally within three weeks.

The **phalanges** are almost always broken by direct violence, so that the distal phalanx, being most exposed, is most often fractured. The violence causing the fracture frequently complicates it by an external wound. Suppurating fractures of the first and second phalanges expose the patient to the dangers of purulent infiltration along the sheaths of the tendons in the palm and the forearm. Extension of suppurative inflammation is especially apt to follow the tendinous sheath of the little finger, for the sheath of this tendon is continuous with the sheaths of the forearm. Prolonged suppuration is apt to destroy the bone, and it almost certainly entails impairment of function from adhesive or destructive inflammation. These compound fractures often heal kindly and

quickly, and the wound may be made to pursue an aseptic course if due care is taken. The soft tissues are often pulpefied by the crushing violence which causes the break.

The DIAGNOSIS is usually easy. Mobility, crepitus, and the history of the accident are the cardinal indications.

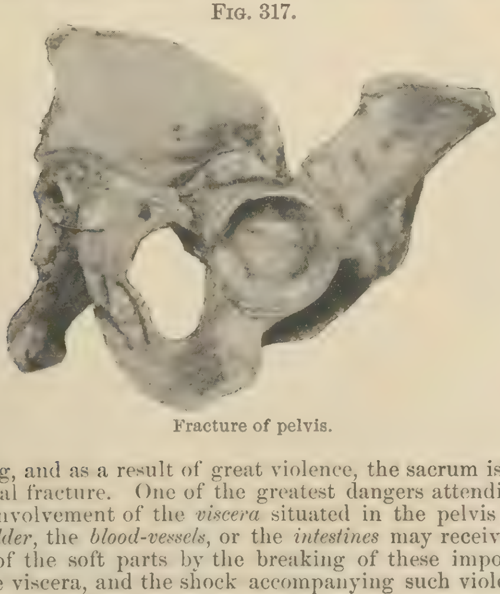
Adjustment of the fracture is not difficult, and maintenance is generally effected by placing the hand on a padded splint with the fingers well supported in a position of partial flexion. The contiguous fingers are valuable supports in the proximal row of phalanges. Extension, as described in the treatment of the metacarpal bones, is sometimes essential, and union is rapid and satisfactory except in suppurating fractures. It is a good rule not to amputate injured fingers unless they are hopelessly destroyed, but the danger of long-continued inflammation in the arm must not be overlooked in the desire to save them.

THE PELVIS.

Fractures of the pelvis are properly divided into two classes—those which implicate the *ring of the pelvis* and those which involve only some of the more *exposed prominences* of the ilium, the ischium, or the sacrum and coccyx. Fractures of the *pelvic ring* are always serious. They are produced by a crushing violence applied to the pelvis and sacrum, by lateral compression, or through violence transmitted through the femur or trochanter.

A double fracture frequently follows a crushing injury, one line of fracture being through the pubic bone, and one through the ilium behind the acetabulum. It is also possible that both the pubic and sacro-iliac joints may be separated by violence transmitted through the leg. A break at the symphysis may also occur from internal violence, as in childbirth. Associated with other fractures

FIG. 317.



Fracture of pelvis.

of the pelvic ring, and as a result of great violence, the sacrum is sometimes traversed by a vertical fracture. One of the greatest dangers attending these injuries is found in the involvement of the *viscera* situated in the pelvis: in this way the *urethra*, the *bladder*, the *blood-vessels*, or the *intestines* may receive serious injury. The contusion of the soft parts by the breaking of these important bones, the laceration of the viscera, and the shock accompanying such violence render these fractures of the pelvic ring most serious accidents.

The most common of the fractures of the pelvic ring are of the *pubic bone.* This may be a separation at the symphysis, but is more frequently a break that involves the horizontal ramus of the pubis and the ascending ramus of the ischium (Fig. 317). The urethra and the bladder frequently suffer injury in this fracture. *Urinary infiltration* is especially dangerous, and if it occur should be promptly provided with free exit and drainage. Fractures of the *true pelvis* are determined by the history of the violence and by the disability they entail. The patient cannot walk, contusion is apparent, mobility is present, and the shock is marked. The viscera give special symptoms. Mobility, and occasionally crepitus, can be determined by pressure upon the anterior portion of the crest of the ilium. When the fracture is in the pubic portion, mobility and crepitus can be detected by direct manipulation.

Fracture produced by violence transmitted through the femur may occur by the head of the bone being forced through the acetabulum, or a line of fracture posteriorly may begin with the sciatic notch and extend through the ilium, and another involve the ramus of the pubis and ischium anteriorly, thus separating a section of the bone, including the acetabulum from the ring of the pelvis. These lines of fracture may extend through the sacro-iliac junction and the symphysis pubis.

Fig. 318.

Great deformity after multiple fracture of femur, with synostosis (Park).

The TREATMENT of either of the fractures last named must include extension applied to the leg. The treatment necessary in most of the fractures of the pelvic ring is rest in bed, with the support of a circular bandage about the hips. Visceral complications will require such attention as is needed to meet the particular indications.

Fractures of the **false pelvis** or of the **ilium** are more frequent, and are not very serious injuries. It seems to me that a portion of the crest may be detached by muscular action in the young adult. The **anterior spine** may also be detached. A break in the ilium usually involves the anterior or the posterior portion of the crest, the line of fracture beginning near the middle and extending in a curved line either forward or backward, the concavity of the curve being upward.

Quiet without pressure is the TREATMENT. Recovery is the rule, but it may occur with deformity.

Transverse fractures of the lower portions of the **sacrum** and of the **coccyx** may occur. The pain is great; the displacement is forward, making an angle which presents posteriorly. Replacement can be accomplished by introducing the finger into the rectum and making backward pressure, but maintenance in a good position is difficult. It has been attained by stuffing the rectum with gauze or with a hollow tube wrapped with gauze. The rim of the **acetabulum** is sometimes

broken, generally as a complication in dislocation of the femur. This is a rare injury. The violence producing it is probably applied directly to the trochanter while the leg is flexed and either rotated strongly outward or inward, the head of the bone being thus driven against the rim. The segment detached is a part of the posterior margin of the ring.

The DIAGNOSIS is not easily made. The dislocation of the femur must be reduced and maintained in position by quiet and extension.

A fracture of the **tuberosity of the ischium** is a rare accident, and is caused by direct violence which produces a severe contusion of the soft parts.

THE THIGH.

Fractures of the lower extremity are one-half as frequent as those of the upper. About one-fourth of such injuries of the lower extremity are of the femur. Fractures of the lower end of the femur are infrequent, those of the upper end are more common, but the middle third is more frequently broken than any other part. The fractures of the upper end include those of the neck, epiphyseal separation, and those breaks which pass through the trochanters. The epiphyseal separation must be very rare as a result of violence. It occurs more frequently however, as a pathological condition.

Fractures of the neck are such as are styled **intracapsular** and **extracapsular** or **mixed**. The intracapsular fractures are those involving the narrow portion of the neck. These fractures occur most frequently in the aged. The increased amount of medullary substance and the diminished amount of cortical and trabecular bone-tissue in the aged weaken very markedly the neck of the femur. This fracture is by indirect violence transmitted through the shaft of the femur or through the trochanters and the neck, or it is produced by a *twist* or *strain* upon the leg in the endeavor to avoid a fall. The capsule of the joint is not necessarily torn and the immediate displacement is not great. The fracture may precede the fall that accompanies it, the fall being consequent upon the fracture, though the reverse is most commonly true. Great violence is not required to produce such a fracture. The loss of function is not necessarily absolute and immediate, patients having been known to walk with such an injury. The *mixed* or *extracapsular* fracture (Fig. 319) occurs in the same manner as the intracapsular fracture, though it may require a little more violence and the line of fracture is not so uniform. It extends through the broader portions of the neck at the base of the trochanter, and is partly within and partly without the capsule of the joint. It may involve one or both trochanters. The line of fracture here, as in the narrow portion (or intracapsular), is more likely to be oblique when the violence is transmitted through the shaft of the femur to the tro-

FIG. 319.

Extracapsular fracture of thigh (original).

chanter and neck. This fracture is also most frequent in the aged. The most common break of this class is along the line of junction of the neck with the trochanter. These fractures are frequently *impacted*, though not necessarily very firmly so.

The deformity in fracture of the neck sometimes shows an anterior angle in the neck of the bone, the posterior portion of the neck being shortened and interlocked, while the anterior surface is separated or not so firmly impacted. This puts the femur in a position of outward

FIG. 320.

FIG. 321.

Impacted fracture of neck of femur (Park).

rotation. The deformity accompanying this fracture is more immediate and marked than in intracapsular fracture. In extracapsular fracture we may have the lesser trochanter attached to the neck.

The DIAGNOSIS and the PROGNOSIS of fractures of the neck of the femur will be here considered, but the TREATMENT is best considered in connection with the treatment of other fractures of this bone.

The *differential diagnosis* between these two varieties is not clear, although now and then the diagnosis of an extracapsular fracture is plain and definite. *The symptoms of a fracture of the neck*, besides the history, are disturbed function, pain, crepitus, eversion, shortening, relaxation of the fascia lata, the abnormal relation of the anterior superior spine of the ilium to the trochanter major, the rotation of the trochanter on a shortened radius, and a fulness of Scarpa's triangle. The diagnosis should be made with as little manipulation as possible; hence the age of the patient and the history of the accident, together with the position, the shortening, the fulness of Scarpa's triangle, and the relations of the trochanter, should be grouped and considered before manipulating the patient. The age is usually above fifty and the history often one of slight violence. The position of the limb is suggestive: it looks helpless, and lies usually in an everted position on the bed, with the muscles and fascia relaxed. The lessened tension of the fascia is noticeable above the trochanter. The function of the limb is impaired or completely lost. The patient is sometimes able to flex the thigh and lift the foot from the bed without much pain. The individual can in exceptional cases walk for a short distance after the injury has been received.

The pain of this fracture is generally very severe. Any motion or muscular spasm causes sharp exacerbations, and there is a dull aching pain even when the limb is quiet. *Crepitus* is not uniformly present, but can generally be elicited if care be taken to bring the broken surfaces in apposition. It is not, however, necessarily essential to a diagnosis. Eversion of the limb is almost uniformly present, and is in many cases quite marked, for the foot often rests on its outer aspect. This eversion is produced partly by the violence inflicting the injury, partly by the muscles attached to the trochanter major, as well as by the psoas and iliacus. The natural disposition of the leg is to external rotation when in the dorsal decubitus.

Inversion is sometimes present, due probably to the peculiar relation of the fragments induced by the violence fracturing the neck. The character and extent of the rotary movements are important in making the diagnosis. Rotation of the injured leg causes pain, often develops crepitus, and the trochanter moves in an arc with a shortened radius. This makes a diagnosis of a fracture of the neck of the femur clear. The radius of the arc may in isolated cases be increased, but it is rarely normal if a fracture exist. Where the femur rotates upon its own axis it is pathognomonic of fracture of the neck. This symptom can be easily recognized if the surgeon will follow the trochanter in its movements with the finger. Shortening of the leg is produced by a change in the angle of the shaft with the neck or by a displacement upward of the trochanter and the portion of the neck attached to it. This shortening of the leg can usually be determined to be in the altered neck by verifying the length of the leg from the trochanter to the external malleolus. The extent of the shortening will vary from a fraction of an inch to three inches. The exact amount of shortening in a given case is not easily determined.

For purposes of examination the patient should be either on a fairly firm bed or a table, and the legs must be symmetrically placed with reference to the pelvis. The adduction or abduction, as well as the degree of flexion, must be the same in each extremity. A cord should be stretched between the two anterior superior iliac spines. This should be bisected at right angles by a line passing downward over the symphysis, and the shortening will be determined by the relations of the malleoli with this downward line. It may also be determined by *Bryant's method*, which is as follows: The legs are symmetrically placed; a vertical line is dropped from the anterior superior spine of the ilium on each side, and a line is carried upward from the trochanter to this vertical line, intersecting it at right angles. The difference in the distance from the trochanter to this vertical line gives the amount of shortening of the leg. Fulness in Scarpa's triangle and a widening or a thickening of the trochanter are also worthy of notice as symptoms of a fracture of the neck of the femur.

The DIAGNOSIS of fracture of the neck is often easy and positive, but there are cases where it becomes extremely difficult to determine certainly the existence of a fracture. The differential diagnosis between the intracapsular and the mixed or extracapsular fracture is often impossible. Extreme age, moderate violence, a slight shortening without complete loss of function, suggest the intracapsular fracture. Comminution or a thickening, either primary or secondary, of the trochanter, with marked shortening, indicates extracapsular fracture. Many cases will remain doubtful.

The PROGNOSIS of an intracapsular fracture of the neck is not so

favorable as that of a mixed or extracapsular fracture. It was for a long time a mooted question whether bony union ever occurred in this break, or whether it was always fibrous. It is now known, however, that bony union does occur. The mixed or extracapsular fracture is much more likely to give a good result, for bony union is the rule if the treatment is good. Most authors recommend a guarded prognosis, and admit the possibility of an imperfect result. The prognosis must in many cases be guarded, for it is extremely difficult, and often impossible, to determine certainly whether it is an intracapsular or an extracapsular fracture. Fractures of the neck, occurring as they do in persons of limited vitality, who are old in tissue if not in years, demand extreme care in treatment. The first consideration is, of course, the life of the patient, and, as confinement in a fixed position is not only irksome, but is dangerous to the life of the aged, the prognosis will involve not only the usefulness of the limb, but a consideration of the danger to life. It is wise to treat these cases as if we expected a good result by solid union, for it can generally be attained.

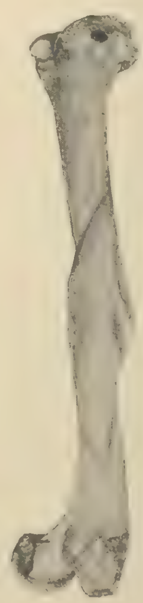
The TREATMENT must be so ordered as to save life even at the expense of an imperfect leg. (See *Treatment* below.)

Fractures of the upper and middle thirds of the femur occur generally as the result of indirect violence. They are usually oblique,

FIG. 322.

FIG. 323.

FIG. 324.



Fracture of upper third of femur.

Overlapping fracture of femur.

the line of fracture being downward, forward, and inward or slightly outward. Fracture in the middle third of the femur by muscular action

is not very infrequent. The violence of the injury may help to determine deformity, but the line of fracture, the contraction of the tibio-pelvic and the ilio-trochanteric muscles, as well as the external rotators, are active agents in the formation of the external anterior angle (Figs. 322, 323). The natural eversion of the leg when the patient is in the recumbent posture is also a factor in producing this deformity in the thigh. The thigh is also shortened. This is partially due to the angling, but an overriding or an overlapping (Fig. 324) of the fragments is also present. Spasm of the long muscles of the thigh is a very constant symptom, exciting pain and increasing the deformity and irritation of the soft parts. The mobility is easily determined, and crepitus is sharp and decided.

The DIAGNOSIS can often be determined by inspection simply, without manipulation. The thigh is slightly flexed, everted, broadened, and shortened, with a distinct prominence on the anterior outer surface of the thigh, which exhibits a marked increase in the anterior curvature at the site of the fracture.

Fractures of the lower end of the femur may be by indirect violence, though they are most frequently due to direct violence. These fractures are classified as are those at the lower end of the humerus. A **supracondyloid** fracture is of the shaft within four inches of the condyles. It has generally a slight obliquity downward and forward, with the lower end of the upper fragment displaced anteriorly and the lower fragment pulled backward. This backward displacement of the upper end of the lower fragment may injure the blood-vessels, as the artery runs close to the bone here. The gastrocnemius, soleus, and plantaris help to increase the deformity. The rectus and the hamstring muscles pull the lower fragment upward, thus increasing the deformity and the danger to the popliteal vessels. The deformity is peculiar in this, that the patella is made prominent by the flexion of the joint produced by the backward displacement of the lower fragment. There is a depression above the partially flexed joint. This supracondyloid fracture is occasionally complicated by a vertical fracture into the joint, separating the condyles. This **intercondyloid fracture** is a serious injury, for it complicates a bad fracture with a lesion of a large articulation, and makes the fracture intra-articular. There is present in this fracture, in addition to the deformity noticed in a supracondyloid fracture, a widening of the joint, and the condyles are pushed apart by the fractured end of the shaft. The capsule of the joint is distended with blood and serum and the mobility is great. Fracture of *either condyle* may result from a fall upon the flexed knee, the violence expending itself on the condyle detached. It may also result from the violence of a

FIG. 325.

Fracture of lower end of femur, with great displacement of condyles (Park).

twist transmitted through the lateral ligaments of the joint, thus tearing off the condyle. The violence may also be transmitted through the head of the tibia to the condyle which suffers the fracture.

The DIAGNOSIS of this fracture is not difficult. The undue freedom of the lateral movements in the extended limb is easily determined and crepitus can be detected. The detached condyle may be displaced forward and backward, but, as the shaft of the femur remains intact, there is no shortening of the leg. An epiphyseal separation of the lower extremity of the femur is a most serious injury, and not infrequently demands amputation.

TREATMENT OF THE VARIOUS FRACTURES OF THE FEMUR.—The principles guiding us in the treatment of fractures of the different portions of the femur have been the subject of wide discussion and very diversified views. This has resulted in many methods of treatment and in a multiplication of apparatus designed to meet the supposed indications. Dr. Allis has called attention to the difficulty in obtaining an accurate adjustment in fractures of the upper third of the femur, and also to the difficulty in maintaining the adjustment. It appears to me, however, that he has exaggerated the latter and underestimated the efficiency of proper extension in accomplishing the purpose. Permanent deformity often occurs in fractures at this site, but I believe that continuous extension will generally control the deformity. Imperfect extension will not do it. Dr. Allis suggests that we cut down upon the fractures of the upper third, adjust the fragments, and keep them in position by fastening the ends together with ivory pegs, steel pins, or wire.

Oblique fractures in any part of the shaft may gradually find a perfect adjustment under the influence of continuous traction, but the transverse fracture with lateral displacement and overlapping requires more than a complete extension to secure this end: it must also have direct lateral pressure to force the fragments into position. Failing in this way to accomplish the purpose, success may be obtained by increasing the angular deformity until the ends can be put in apposition, and then with extension and gradual straightening of the leg, while maintaining firm lateral support at the fractured point, the fragments may be set or properly adjusted. It is not easy to determine that adjustment is good, for the bone is enveloped in a mass of muscles and so placed that it cannot be distinctly outlined. The intercondyloid fractures require not only extension, but lateral pressure on the condyles, in order to secure good apposition in the vertical line of fracture.

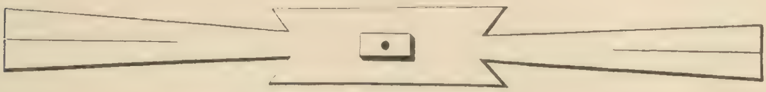
Every form of splint devised for the treatment of fractures of the femur is designed to meet the acknowledged need for extension, and in addition to this some of them utilize lateral support. All surgeons admit the value of traction, although many deny the wisdom of relying solely upon its efficiency for the result desired. It is quite difficult to obtain good lateral support for its fractured ends through the great mass of muscles which envelop this bone. The soft mass of muscles prevents the lateral pressure from accomplishing the purpose for which it is intended. The muscles rapidly atrophy under the influence of rest and pressure, and the lateral support becomes inefficient unless it is reapplied. The problem in treatment is to secure the best extension, with such lateral support as is needed, with the least discomfort and the greatest freedom to the patient.

The double inclined plane has been discarded.

Buck's extension by weight and pulley with the leg and thigh in the extended position is adopted by many surgeons. It is also used in conjunction with some

form of a long side-splint by surgeons who are not willing to rely solely upon extension. Lateral support is also given by sand-bags placed alongside the thigh. Buck's extension is applied in the following way: A strip of moleskin plaster four inches wide, and long enough to have the free ends extend above the knee when the centre of the strip passes loosely across the sole of the foot, is to be used as a

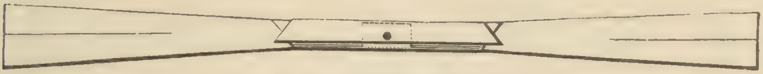
FIG. 326.



Extension-band and foot-piece.

medium for making extension. A flat piece of wood, three by four inches, with a hole in its centre, is placed in the middle of the long strip. A cord passes through this wooden piece and also through the moleskin plaster. The adhesive strip is placed in contact with the skin along the sides of the knee, and is held firmly in

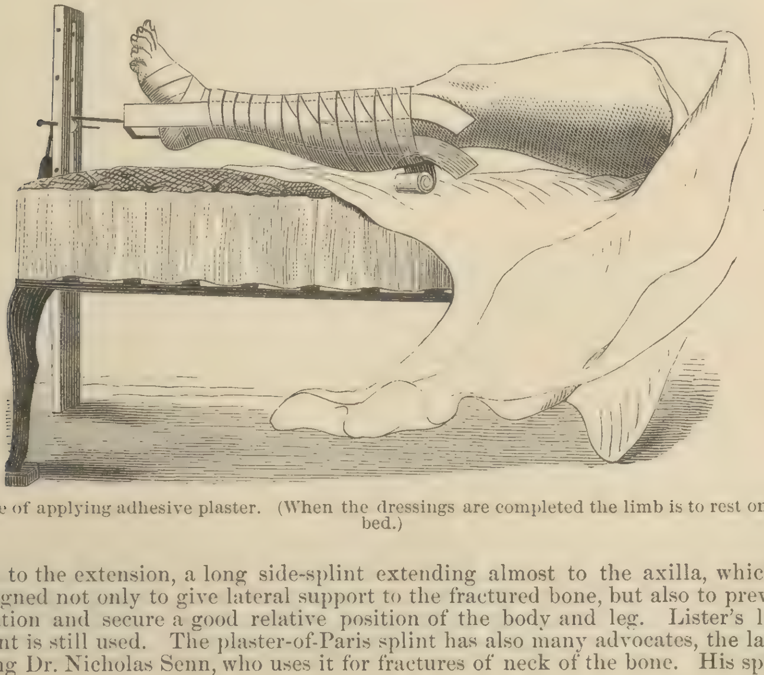
FIG. 327.



Same, folded and ready for use.

position by a roller bandage which should envelop the leg as high as the plaster extends. The cord that passes through the foot-piece is carried over a pulley at the foot of the bed, and continuous extension is made by a weight, the leg and thigh resting on the bed or on cushions (Figs. 326–328). Hamilton uses, in addi-

FIG. 328.



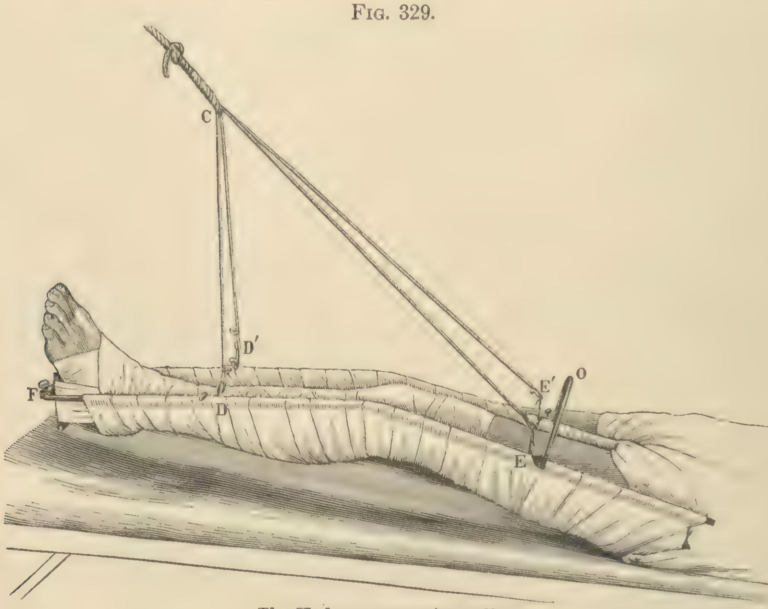
Mode of applying adhesive plaster. (When the dressings are completed the limb is to rest on the bed.)

tion to the extension, a long side-splint extending almost to the axilla, which is designed not only to give lateral support to the fractured bone, but also to prevent rotation and secure a good relative position of the body and leg. Lister's long splint is still used. The plaster-of-Paris splint has also many advocates, the latest being Dr. Nicholas Senn, who uses it for fractures of neck of the bone. His splint

envelops the foot, leg, thigh, hips, loins, and abdomen, and is applied under anæsthesia while firm extension is made. He also thinks it absolutely necessary to envelop the thigh of the other side in the dressing, and includes in the dressing for the injured bone an apparatus for applying pressure directly on the trochanter major by a set-screw. The plaster-of-Paris splint is used for the shaft of the bone. The plaster-of-Paris dressing is an inefficient agent for extension, and as applied by Dr. Senn for fracture of the neck of the bone implies such rigid confinement that it appears to me it cannot be borne by many aged patients.

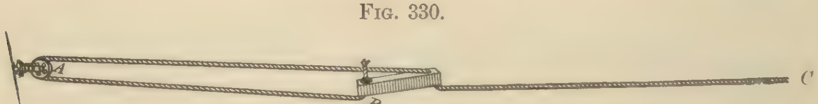
Simple and continuous extension was, I think, first obtained in oblique suspension by Nathan R. Smith when he introduced his anterior splint, of which the Hodgen suspension splint is a modification. The advantages of the Hodgen splint are—(1) The most equable perfect and comfortable extension yet devised. (2) Easy adjustment. (3) It leaves the thigh exposed for inspection. (4) The muslin supports on which the leg and thigh rest can be separately adjusted, so that the tension on any one of them can be easily changed and the normal anterior curvature can be maintained, notwithstanding the rapid atrophy of the soft tissues. The fractures in the shaft and in the lower end of the femur can be very perfectly immobilized in this splint. Clinical results and theory confirm me in the belief that it comes nearer adjusting and immobilizing the fractured ends of a break in the neck than any other method of treat-

Fig. 329.



The Hodgen suspension splint.

Fig. 330.



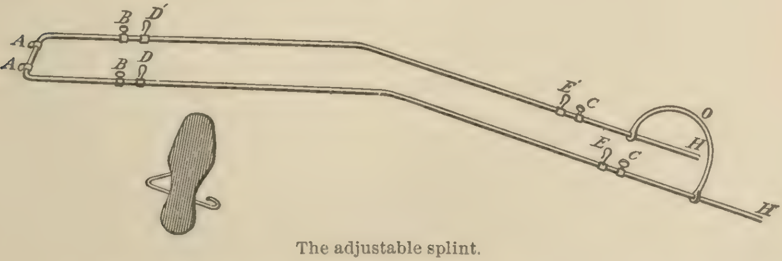
ment devised. If the ends are in apposition, the movement should be easier at the head than in the fracture. The head of the femur should move with the neck if adjustment is good; the swing of the leg does not imply that the movement is at the break.

Moderate extension approximates and sets the fractures of the neck. The impacted fractures at the base are not disturbed by moderate equable extension. Displacement by rotation can be avoided in this splint. If pressure upon the trochanter is desired, it can be secured by a flannel bandage about the hips. The freedom of the motion allowed the patient does not interfere with the union of the broken shaft, as the splint and the leg are free to move with the body of the patient. The only motion is at the hip-joint, and there is no possibility of angling at the fractured point by the dragging of the leg on the bed as the patient moves from one side to the other. The patient can sit upright in bed or use the bed-pan without disturbing the fracture.

This Hodgen splint[1] is composed of a single piece of No. 2 wire, bent as shown in Fig. 331. The sliding hooks, D D′ and E E′, are used for attaching the suspending cord to the splint. The use of the arch O is to maintain the proper width of the upper end—viz. eight to ten inches. This arch is loose and is easily slipped into position over the ends of the wire which forms the splint before the latter is applied to the leg. The width of the splint at the foot is about five inches, and is determined by the bend in the wire which forms the body of the splint. The wire hooks, E E′ and D D′, present at one end a free loop for the attachment of the supporting cords, while the other side is coiled somewhat snugly around the lateral bars of the splint at D D′ and E E′. The lateral bars extend upward on each side of the leg, so that the two ends of the wire reach, the inner one to a point above the pubes, and the outside one nearly to the crest of the ilium. The bend of the splint at the knee permits slight flexion of the leg. The suspending apparatus is composed of—first, the pulley A (Fig. 330), which is fixed in a high framework at least ten feet above the level of the bed, or preferably in the ceiling; secondly, of the perforated sliding block B and the cord A B C; thirdly, of the two cords D C E and D′ C E′ (Fig. 329) of equal length, with a loop at each end for attachment to the wire hooks at D′ E′ and D E. These cords are passed through a loop in the cord B A C at its end C. The suspension of the leg and splint is readily accomplished by sliding the block B downward on the cord B A C (Fig. 330). The amount of extension is determined by the degree of obliquity of the cord B A C. It is transmitted from the splint to the leg through the adhesive strip H (Fig. 329), which, extending from the lower part of the thigh down the leg across the board N at the sole of the foot, is fastened by a cord to the crossbar at F, and thus securely holds the leg in the splint.

In Fig. 331 an adjustable splint,[2] easily fitted to any leg, long or short, is shown. It is composed of hollow tubes and sliding bars, as described below:

Fig. 331.



The adjustable splint.

the lateral bars B C are square tubes furnished with thumb-screws at their extremities, B and C. These tubes are of sufficient size to admit the terminal ends of the lateral bars, and by pushing in or pulling out the extremities of the lateral arms the length of the splint may be varied. Its width can also be

[1] It can be made by any blacksmith. [2] Sold by Aloe & Co., St. Louis, Mo.

changed by sliding the lateral arms into the hollow tube A A, which is furnished with thumb-screws at A and A. The hooks D D′ and E E′ for suspending the splint slide on the lateral bars B C, but should be kept near the end of the hollow tubes B C.

The application of the Hodgen splint is simple and in skilful hands is painless. Suppose the leg with its fractured femur to be resting upon the bed. The adhesive strip with its foot-piece and cord is placed in position: an assistant grasps the foot with one hand, and with the other hand under the knee lifts the leg from the bed, while at the same time he makes steady extension of the femur. The surgeon then applies the roller as high as the plaster extends, binding it to the limb. The leg is again allowed to rest upon the bed: the assistant maintains moderate traction on the foot so that the extending force applied to the fractured bone may be continuous. The splint is then put into position. The lateral arms of the splint are held apart by a metal arch; one arm of the splint is placed upon either side of the leg, and the crossbar is brought close to the sole of the foot. The cord secures block B (Fig. 330) to the foot of the splint. Strips of muslin are passed under the leg —one at the ankle, one at the knee, and perhaps two under the thigh. These are secured by pins to the lateral arms of the splint, while it is held so that the inner arm extends above the pubes and its outer arm reaches nearly to the crest of the ilium, the lower end of the splint being on a level with the malleoli. The inner wire may be shortened or bent upward so as to give the patient opportunity to sit upright, but it should always extend to a point in front of the pubic bone. The leg can now be suspended by attaching the cords D C E and D′ C′ E′ (Fig. 329), and adjusting the slide B so as to lift the splint and leg from the bed. The cradle, of cloth strips, upon which the leg is to rest is now made complete by adding strips of muslin and adjusting them to the outline of the leg as indicated in the cut.

No special or violent attempt to adjust the fractured bone is made except where there is lateral displacement of a transverse fracture. The free swing of the leg and the efficiency of the extending force secure adjustment of the ordinary oblique fracture in a few hours. The flexion of the leg on the thigh should be very slight, not more than an angle of 170° or 180°; for if the bend approaches a right angle, the elevation of the knee is necessarily great, and most of the extending force applied to the thigh would be through the muslin strips on which the upper part of the leg rests (those just at and below the bend of the knee). The angle of flexion at the knee may be varied from that of the splint by lengthening or shortening the strips which support the thigh. The foot may be elevated or lowered, and the support rendered by the muslin strips under the thigh varied by sliding the loop at C downward toward the foot or upward toward the groin. The flexion of the knee is only sufficient to put the leg in a comfortable position, slightly relaxing the tension of the hamstring and gastrocnemius muscles. The slight flexion of the thigh on the pelvis with extension puts at rest the psoas and iliacus and the rectus extensor of the thigh. External rotation, if it occurs, can be obviated by securing the foot to a foot-piece or by a muslin strip passed around the outer border of the ball of the foot and fastened to the inner arm of the splint. A foot-piece can be easily adjusted to the splint if it is thought desirable to steady the foot in a fixed position.

The degree of extension necessary to accomplish the result desired may be determined in part by the sensations of the patients. It is never necessary, when using this splint in the adult, to apply (as recommended by Hamilton when speaking of other methods of making extension) twenty pounds as an extending weight. An extension of twenty pounds, applied through an adhesive strip to the leg and pulling upon the knee-joint and femur, is a serious trial to the

patient's endurance, and it taxes the surgeon's ingenuity to steadily maintain such a force. The amount of extension required in this suspension splint is much less, being from three to ten pounds. There is no friction to overcome, and so long as the patient remains in bed there is no appreciable variation in the extending force, provided the point of support is ten feet or more above the plane of the bed. It is a quiet, persistent, non-irritating, effective pull. There is no perineal band to fret and worry the patient. The extending force is determined by two factors, and these are entirely within the control of the surgeon—viz. the obliquity of the extending cord and the weight suspended. The first can be varied by the relative position of the bed and the suspending pulley, and the latter can be increased, if desired, by placing sand-bags across the lateral bars of the splint.

It seems difficult for some surgeons to understand how extension can be applied to a fractured thigh by direct traction upon the leg without counter-extension through the perineal band. They fail to recognize the efficiency of the weight of the leg as an extending force and the stability of the body as a counter-extending force. The amount of the extension in a particular case where the patient weighed one hundred and fifty pounds was calculated mathematically and estimated at 6.1 pounds. The suspending cord in this case formed an angle of 15° with the perpendicular, and the weight of the leg was estimated as being twenty-one pounds. The suspended limb should not be raised much above the bed, the heel remaining within two inches of the bed. If the pulley from which the splint is suspended is fixed in a ceiling that is nine feet to twelve feet high, a perpendicular line dropped from the pulley should fall beyond the foot of the adult patient. In the case of a child, where the weight of the leg is less, the obliquity of the cord should be greater. The obliquity of the cord should be sufficient to make an angle of from 15° to 35° with the perpendicular. The point of fixation for the pulley for suspension should not be nearer the plane of the bed than ten feet. This gives the patient the full liberty of the bed without changing materially the extending force. The inclination of the patient to slide toward the foot of the bed may be obviated by raising the foot of the bed by means of blocks. In the case of a child it may be well to pass a cord loosely about the body under the arms and fasten it to the head of the bed, to serve as a check to any great change in the position of the patient.

The nutrition is undisturbed, for the circulation is not interfered with by the pressure of retentive apparatus, and it is as perfect as it can be during enforced quiet. The leg can be kept cool or warm as desired. The patient may sit up or lie down as comfort suggests. The bed-pan can be used without disturbing the fracture, and the best possible result can generally be obtained—viz. early union with no appreciable shortening. This is obtained without bed-sores or any of the constitutional complications which are liable to follow confinement in a fixed position.

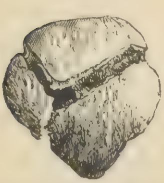
The splint is well adapted to the treatment of all fractures of the femur, whether they are intra- or extracapsular, through the trochanters, the shaft, or the condyles. The results of the treatment of fractures of the neck of the thigh with this splint are very satisfactory in the majority of cases. Most of the unsatisfactory results obtained are probably due to imperfect adjustment of the fractured ends, or are found in the fractures that occur in the neck very near the head. The feeble, aged persons who are most liable to this injury derive comfort from the use of the Hogden splint, for the freedom of motion it gives is greater than

they can obtain with any other apparatus, or than pain will permit if the injured member is allowed to go without treatment. The spasmodic or violent contraction of the muscles of the thigh when the fracture is in the shaft is sometimes so great in nervous children that Buck's extension with the leg resting upon the bed, and the lateral support of sand-bags about it, is best for a few days. After this irritability subsides the leg is more comfortable and more efficiently treated in the suspension splint. This spasm subsides after a few days, but provokes by irritation an increased exudative deposit about the break. I find that a sand-bag partly full, placed on the thigh while it is in the suspension splint, materially mitigates the spasmodic action. Clonic contraction will, in isolated cases, occur with any splint and under any plan of treatment, for no lateral support nor compression can prevent the contraction which accompanies a muscular spasm. Sulphonal or, if necessary, opiates, will help to control this clonic spasm, and may be given to nervous children with advantage for a few days after such an injury. This method of applying extension affords a most perfect means of neutralizing the tonic contraction of the muscles. The oblique suspension gives equable and continuous extension of an amount sufficient to accomplish a perfect result without the waste of any force, and it ensures the patient the most perfect liberty attainable by any known means compatible with comfort and safety.

The Patella.

Fracture of the patella is the most frequent during the period of greatest muscular activity—that is, between the ages of twenty and forty years. The patella may be fractured by direct or indirect violence. Indirect violence is inflicted by *muscular action*. The fracture inflicted by muscular force is in the majority of cases transverse, and occurs in the lower half of the bone. The violence may be purely muscular, or, as often happens, may through a fall be combined with some degree of direct injury. The fracture is usually complete, and it is evident from the swelling, loss of extending power of the leg, and by the mobility and more or less marked separation of the fragments. The power of extension may not be completely lost, but it is always enfeebled. The fascia extending laterally from the patella over the joint may not be extensively torn, and through the influence of the vasti some degree of power of extension may still remain. The swelling is not only in the tissues about the knee-cap, but the capsule of the joint is distended by the hemorrhage resulting from the fracture and by a serous effusion into the irritated joint. This swelling may materially influence the degree of separation of the fragments.

Fig. 332.



Comminuted fracture.

The **transverse fracture** may be compound from the violence of a direct blow. Fractures by direct violence are more uncertain and irregular than when caused by muscular action. The separation of the fragments in a fracture produced by a direct blow upon the patella is not apt to be so great as where the line of fracture is transverse and largely the result of muscular action. The lines of the fracture may be

stellate or vertical, and the displacement very slight, for the tissues on the superficial surface of the bone may not be completely separated. A compound fracture of the patella is not very infrequent, and, as the knee-joint is in these cases exposed to the dangers of infection, it is a much more serious injury than a simple one. In such cases the utmost care is demanded to preserve aseptic conditions and avoid suppuration.

The TREATMENT of the fractured patella is generally conservative and efficient. Extensive effusion of blood and serum, with consequent distention of the capsule of the joint and marked infiltration of the surrounding tissues, sometimes delays the adjustment of the fracture, though immediate adjustment is generally possible. The preliminary treatment for the first three or four days should be such as to limit and control the reparative action. Equable and slight compression applied by a well-adjusted bandage and the use of cold applications should be resorted to at once. The treatment is most efficiently carried out by some firm or fixed dressing which shall keep the limb in an extended position, give complete rest to the joint, and limit the movements of the muscles of the thigh. Hence the splint should include the whole length of the thigh as well as the leg. Moderate compression of the muscles of the thigh lessens the contraction of the quadriceps extensor. The best splint to subserve this purpose is the plaster-of-Paris splint, which should steady the foot and extend to the groin and gluteal fold. It should be supported and strengthened by tin strips incorporated in the sides of the splint. This splint should have a large oval fenestrum cut in its anterior lateral surface, in order that the region about the patella may be thoroughly exposed to the surgeon's view.

FIG. 333.

Fracture of the patella, illustrating impossibility of securing bony union because of intervention of ligamentous and soft tissues (Park).

The separated fragments of a transverse fracture may then be drawn together by strips of plaster passing over a compress placed above the patella. The two ends of the strips are carried obliquely downward toward the calf of the leg and secured to the splint. Traction is thus made upon the upper fragment, drawing it downward. Another strip may be carried across the ligament below the knee-cap and upward toward the posterior surface of the thigh, and likewise fastened to the splint. The traction upon these strips of plaster may cause some tilting of the fragments at the line of fracture. This can be controlled by a compress placed over the surface of the patella and held in place by a bandage about the splint. It is a great source of comfort and security

to the patient to have this plaster splint suspended, so that the leg can move with the patient. The Hodgen splint should be used for this purpose.

Many devices have been used for the approximation of the fragments. Malgaigne's hooks have been used for this purpose, as also subcutaneous ligature and the wiring of the fragments. The dangers attending operative measures have rather discouraged their general adoption. The results obtained by a conservative method are so good that the operative treatment is certainly not generally advisable, though in proper hands many cases will justify operation. It is particularly applicable in refractures of the patella and in those fractures which have united badly, leaving the function of the limb much impaired. There is no question but what bony union occasionally results from conservative treatment, but close fibrous union is the usual result. A short ligamentous union gives the leg good functional activity. Good strength and good functional use of the leg may result even where the fragments are separated for an inch or more, if the ligament is firm.

The leg should be kept at rest with the patient in bed for five weeks. He should then continue the use of crutches for six weeks longer. A limited use of the leg, aided by a cane, should be continued still longer. This carries the patient over a period of three or four months. Rubbing and moderate flexion of the knee in order to secure perfect function will have to be continued for a longer time.

A compound fracture with suppuration requires free drainage and the best antiseptic precautions to limit the suppurative process. Compound fractures should be approximated by fastening the fragments together by wire or ligature. The wiring of the patella to secure union for a transverse fracture with wide separation may be used in simple fractures where every antiseptic precaution can be enforced. The union is more rapid and more certain than where treated in a conservative way. A patient who does well under operative measures may return to work in two or three months. The wire loops used on the fragments of the patella should not be passed into the joint, but should penetrate the fragment of the bone and emerge at the superficial surface, where they can be twisted together and flattened upon the bone. Strong kangaroo tendon may be used for this purpose.

The Leg.

The tibia and fibula should be separately considered in the study of fractures of the leg.

Fractures of the tibia are classified as of the **upper and lower ends** and of the **shaft.**

Fractures of the **head of the tibia** are usually by direct violence. The fibula may be broken with it or may be torn from its tibial attachment. The displacement is apt to be more marked if the ligaments uniting it to the tibia are broken.

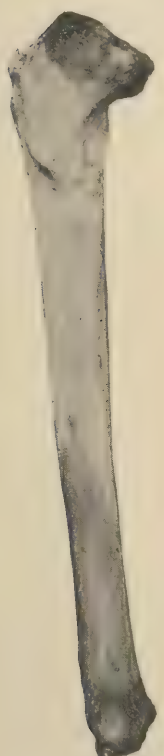
A transverse fracture below the tubercle (Fig. 334) is not infrequent.

Fractures of the upper end of the tibia, **implicating the joint,** are slow in uniting. Fractures in the lower end and of the shaft of the tibia usually unite in five or six weeks, but in the upper end, even where the joint is not involved, they are slower and may require three or four months. Violence transmitted through the shaft of the tibia may detach a condyle. Swelling about the site of fracture is supplemented by swelling of the distended sac of the joint when the fracture enters the joint.

The knee-joint must be put at rest, hence the splint must include both the thigh and the leg. Some lateral support should also be given to the tibia at the site of fracture. The plaster-of-Paris splint is well adapted to the treatment of these fractures. If adjustment is good, even if the injury be compound, suppuration may be avoided by careful attention to antiseptic details. If suppuration occur in the joint, free drainage by incisions properly made must be obtained. The Hodgen suspension splint with oblique extension is admirably suited to the treatment of these cases. Extension is often essential to the most perfect results. The lateral support secured by a roller bandage or by a many-tailed bandage may be useful in conjunction with the Hodgen suspension splint.

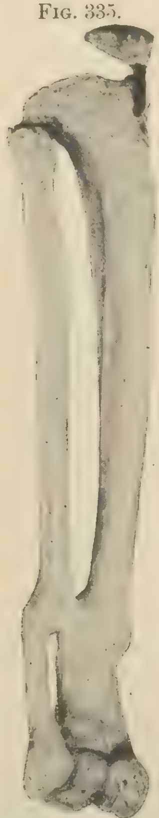
Fractures of the tibia may occur at any portion of the *shaft*, but are most frequent in the lower half of the bone. Fracture by indirect

FIG. 334.



Fracture of upper end of tibia.

FIG. 335.



Transverse fracture, with anterior displacement.

FIG. 336.

Line of fracture, at junction of lower third and middle third of tibia.

violence is frequent at the junction of the lower and middle third. It is said that torsion plays a considerable part in determining this fracture. The line of fracture in this part of the bone is downward and forward (Fig. 335), so that the end of the upper fragment has a sharp point ante-

riorly. The displacement is almost always of the anterior fragment forward and outward. The shortening is determined either by the violence inflicting the injury or by the contraction of the gastrocnemius and soleus muscles. The anterior projection of the upper fragment may be in part due to the action of the quadriceps extensor of the thigh.

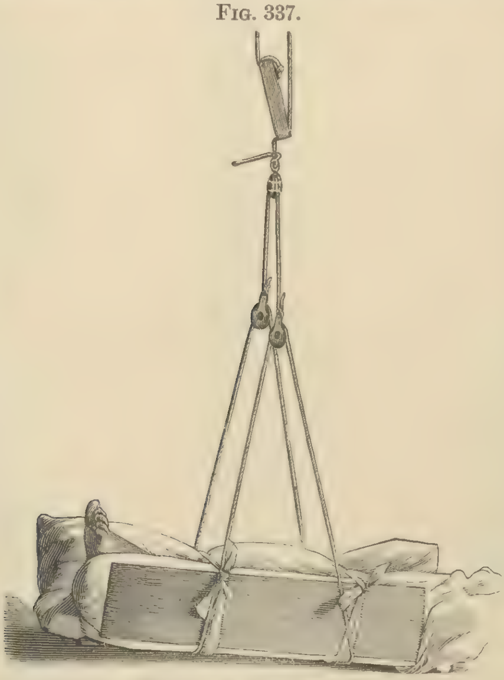
Fractures of the shaft are very generally accompanied by a fracture of the fibula at a point a little above the line of fracture of the tibia. (See Fig. 336.) The lower fragment of the tibia is frequently broken or split into more than one piece. The split bone sometimes enters the ankle-joint. Fractures of the tibia, whether by direct or indirect violence, are apt to be compound.

The SYMPTOMS are loss of function, pain, mobility, and deformity due to the anterior projection of the upper fragment. Injury to the great vessels in fractures of the tibia, whether of the upper end or the shaft, are not infrequent.

Reduction of displacement in the shaft of the tibia can usually be accomplished by traction upon the foot. The reduction is not always easily maintained where the obliquity is marked and the displacement great.

The contusion and swelling which usually accompany these fractures often make it unsafe to put the leg into a plaster-of-Paris dressing at once. While these

FIG. 337.



Fracture-box suspended.

conditions exist and prevent the use of the plaster splint, the bivalve cushion or pillow makes a most admirable support for the fracture. A feather or moss pillow makes good padding for this purpose. The pillow should be placed about the leg,

and the lateral support given by a fracture-box composed of three loose boards. The wooden strip on the posterior surface of the leg should extend from a point below the sole of the foot to the fold of the joint behind the knee. This board should not be wider than the leg at the calf. The two lateral boards should be wider, being about five inches in width, and should extend from below the sole of the foot to a distance of four or five inches above the knee-joint. The leg is placed in the middle of the pillow, and the sides of the pillow are brought up on its lateral surfaces. The lateral boards are now pressed against and give support to the leg and foot, the amount of pressure being determined by the tension put on the bandage strips which pass about and envelop the splint, the pillow, and the leg. If the upper fragment is disposed to push forward, it may be somewhat steadied in position by a firm compress placed over it and secured by a strip passing about the fracture-box at the site of injury. This splint may be replaced in a week or ten days by a plaster-of Paris splint. This fracture-box is very well adapted to the treatment of these fractures, for it fulfils the conditions to be met in compound fractures. The leg can be inspected without disturbing it, and it can be kept clean. Good support is given by lateral pressure. Stability of position is almost essential to kindly healing of compound fractures. Hence the removal of a portion of the end of a bone, in order to relieve tension and to give easy adjustment, is justifiable in these compound fractures if the fractured surfaces cannot be held accurately in position by the fracture-box or by nails or pegs passed through the fractured surfaces. This fracture-box may be suspended, and the patient can move without disturbing the fracture.

If the injury to the soft parts be not too great, and the fracture be easily retained in position, a plaster-of-Paris splint may be at once adjusted. The danger of making the plaster splint too tight may be obviated by enveloping the leg in a thick layer of cotton batting: the common non-absorbent cotton is the best. A plaster-of-Paris roller is then applied. A *stirrup* made from strips of old sheeting into which the plaster-of-Paris is rubbed makes a good splint. This plaster stirrup should be about three inches wide and composed of six or eight thicknesses of cloth. It should be placed outside the cotton and extend from a little above the knee downward across the sole of the foot and up on the other side of the leg to a position opposite the point of beginning. This is secured to the leg by a simple roller bandage. The bandage can be cut in front and the leg inspected at any time without disturbing the plaster stirrup.

In the obstinate cases of anterior displacement of the upper fragment the tension exerted through the Achilles tendon may be relieved by subcutaneous division.

Fractures of the *lower end of the tibia* may be either by direct crushing or indirect violence. Most frequently these fractures are produced by the transmission of violence through the foot. This fracture may involve both bones above the joint or make a comminuted fracture of the lower end of the tibia. The fracture, if above the joint, is to be treated much as a fracture of the shaft of the tibia.

Fractures of the *lower end* involving the joint are inflicted either by eversion and outward rotation of the foot, producing a Pott's fracture, or by inversion with inward rotation, producing fracture of the fibula about an inch and a half above its lower extremity, as well as fracture of the tip of the internal malleolus. This fracture does not usually produce serious deformity. The displacement is easily corrected, and the result of treatment is generally good.

Pott's fracture, the one produced by eversion and outward rotation of the foot, has three separate lines of fracture: one of the tip of the

internal malleolus, another of the fibula two and a half inches above the lower end; the third, not always present, is through the outer margin of the articular surface of the tibia. When the outer portion of the articular surface of the tibia is broken from the shaft, it may be pushed upward between the tibia and fibula. This fracture, if complicated by the displacement of this wedge-shaped fragment, is a serious injury.

Fig. 338.

Pott's fracture (Hoffa).

Fig. 339.

Exaggerated deformity in Pott's fracture.

The SYMPTOMS of such a fracture are the outward eversion of the foot, the prominence of the internal malleolus, and tenderness at the site of fracture of the fibula, together with a widening of the articulation (Fig. 339).

The adjustment can usually be accomplished by traction upon the foot with pressure upon the external malleolus. In these fractures the foot is often displaced backward, so that the anterior margin of the tibia presents forward on the astragalus. The treatment of these fractures is usually best accomplished by the application of a plaster-of-Paris splint. It will often be necessary to delay the application of the plaster splint until the swelling of the parts has subsided, but the adjustment of the displaced bones must be at once perfected. They can be retained in position by the fracture-box with lateral compression, as described above for use of fractures in the shaft, and by a plaster-of-Paris splint.

Fractures of the *upper half of the shaft of the fibula* without a break of the tibia are by direct violence. Fractures of the *lower half* result most frequently from indirect violence. The upper end of the fibula

may be broken by the action of the biceps muscle or by a twist or turn of the leg. Fractures in the lower end of the fibula frequently result from forcible eversion or inversion of the foot. The displacement of the fragments in fracture of the fibula is not usually very marked. It is more evident when the injury is of the lower third than when in the shaft or upper end. The attachments of the muscles and interosseous membrane prevent a very wide separation.

Fig. 340.

Union with backward displacement of foot in Pott's fracture.

The TREATMENT of fracture of the shaft and lower end is by immobilization of the ankle and foot with a plaster-of-Paris splint. This treatment should also be followed in fractures of the upper end. Union is usually rapid and satisfactory. In fractures of the upper half of the fibula the splint may be removed in three or four weeks, but when the lower half is broken the splint should remain longer.

Ambulatory Method of Treatment.

Fractures of the leg and thigh are now not infrequently treated by the so-called ambulatory method. This means something more than permitting the patient to move around with crutches with some fixed dressing applied to the break. The object is to so arrange the dressing as to enable the patient to use the leg in locomotion. The various forms of hip-splints used for immobilizing and securing extension for hip disease may be used in this way. The splint with a body band, a perineal band, or an inside steel bar, with ischiatic crutch and a cross-bar below the sole of the foot, on which the weight of the body falls in walking, is most useful. The fracture is to be enveloped by lateral supports,

which should fit snugly and give some pressure to the soft parts. Extension is to be secured by fastening the foot to the cross-bar. The lateral support may be secured by a snug-fitting plaster cast.

It is claimed by advocates of this plan of treatment that a simple plaster-of-Paris splint so adjusted as to have the thick sole of the splint separated from the foot by a layer of cotton (one inch or more), and made to encircle snugly the tuberosities of the tibia, will afford a good medium of locomotion and firm support for the break.

The ambulatory treatment is valuable in exceptional instances, and should be used; but in many cases an enforced rest for the body and the leg will be most advantageous to the patient. The advantages claimed for this method are, first, a more rapid and less uncertain union of the break; second, a more satisfactory and perfect restoration of function, since there is less atrophy of muscle and a diminished stiffening of the joints; and, third, the value of the time secured to the patient by the short confinement to the bed or house.

The Foot.

The **bones of the foot** suffer fracture by direct and indirect violence. The **astragalus** may be crushed by a force transmitted through the tibia. There is no uniformity in the line of fracture through the astragalus, and the DIAGNOSIS is difficult, and is occasionally impossible unless the fragments are displaced. The displacement of one of the fragments, usually of the neck, is not infrequent. If it cannot be put into good position, it should be removed. If the fracture be compound and the bone be comminuted, or if the displaced fragments suppurate, it is best to remove them.

The results of treatment of fractures of the astragalus when the displacement is not marked are good. The result, even when it is necessary to remove a part of the bone, is also good. Immobilization of the ankle in a position at right angles to the axis of the leg is the treatment to be pursued. This is best secured in a plaster-of-Paris splint.

The **calcaneum** may be broken by a fall upon the foot or by the violence conveyed through the tendo Achillis in contraction of the gastrocnemius and soleus muscles. Where the fracture is the result of a fall upon the foot the bone may be comminuted.

Flattening of the sole of the foot, absence of the prominence of the heel, with pain and disability, constitute the SYMPTOMS attending such a fracture. The parts are to be moulded into as good a position as possible and treated by immobilization. If the injury be compound and the fragments small and detached, they should be removed. Where the fracture results from muscular contraction the position maintained should be that of extension of the foot.

The **metatarsal bones** are broken by direct violence. The first and fifth metatarsal bones, being the most exposed, are the ones which are usually broken. Contusion of the parts about the site of fracture is very common, and the fracture is frequently compound. The displacement is not apt to be very marked.

The SYMPTOMS are pain, mobility, crepitus, and tenderness at the site of fracture.

The TREATMENT is immobilization of the foot.

Fractures of the **phalanges** result from direct violence. The bones are often crushed by the violence producing it. Extension applied to the fractured bone may be necessary in isolated cases, but usually the support given by the contiguous toes and by a bandage which covers the foot and toes, putting the foot at rest, gives sufficient stability to the fracture after it is adjusted.

CHAPTER XXXVII.

DISLOCATIONS.

By H. H. Mudd, M. D.

The bones of the skeleton are joined by ligaments or by fibro-cartilage. The union in some cases is so firm that separation cannot occur without fracture, and the resulting injury is to be regarded rather as a fracture than a dislocation. *The separation of the smooth articular surfaces of a joint that has a capsule, even if accompanied by a fracture of bony prominences, is a dislocation.* The displacement need not be so complete as to entirely remove one articular surface from its opposing bone to constitute a dislocation, so that in the surgery of the joints *a dislocation is the complete or partial separation of the articular surface of the one bone from that of another.* The partial luxation which accompanies a *sprain* is momentary, the displaced bone returning at once to its place. If the displacement by muscular action or the tension of the ligaments remains unreduced, even if the articular surfaces are not entirely separated, it constitutes a dislocation. Dislocations are less frequent than fractures, being in the proportion of one to eight or ten.

Dislocations are *traumatic*, *pathological*, and *congenital*, occurring in frequency in the order named. **Traumatic dislocations** result from direct and indirect violence and from muscular action. We are chiefly concerned with this class. In the **pathological dislocation** the elements determining the accident are slow changes in the ligaments and tissues of the joint, muscular action being the active agent in producing the ultimate displacement.

The **congenital dislocations** are those which occur in the child from errors in the development of the joint, and not such as are produced by the violence inflicted during the delivery of the infant.

The *distal bone* forming a joint is the one spoken of as being *dislocated;* rarely, as of the acromial end of the clavicle, is the proximal bone the one displaced.

If there be a wound of the skin which communicates with the dislocated joint, it is characterized as a *compound dislocation.* Special indications for treatment may arise from other important complications, such as laceration of nerves and vessels or fractures.

Dislocation of symmetrical bones are *bilateral* or *double.* When both ends of a bone are displaced it is said to be double or total. If two or more bones are simultaneously dislocated, the displacements are said to be multiple.

The particular point to which the distal bone of the joint mentioned is displaced often gives name to the special dislocation, as subcoracoid dislocation of the humerus.

If the dislocated bone remains at the point where it first comes to rest, it is primary, but if after a time, under the influence of muscular activity or pathological changes, it shifts to another point, it is a consecutive or secondary dislocation.

Etiology and Mechanism.

The anatomy of a joint and its exposure to violence determine its predisposition to dislocation. The ball-and-socket joints have the greatest range of movement, and are on that account most liable to this accident. The shoulder is the ball-and-socket joint having the freest motion, and it suffers more than half of all dislocations. Dislocations of the shoulder are rare under the twentieth year, but dislocation of the elbow is frequent. The relative frequency of the dislocation of these joints is reversed after this age, and the frequency of the shoulder displacements is much increased during middle life. The infirmities of extreme old age prevent exposure to the accidents likely to result in dislocation. Dislocations are not as frequent in females as in males.

Dislocations are rare in children and in the aged, separation of an epiphysis and fracture being respectively more apt to occur in these periods of life. People with loose joints and lax ligaments are peculiarly liable to dislocation. The determining cause of a traumatic dislocation is external force applied either directly to the joint or, as is most often the case, indirectly through the bones constituting the articulation or by muscular action. Dislocations by indirect violence are very much more frequent than by direct violence. *Muscular action alone* rarely produces a dislocation, but it frequently produces secondary displacement in existing dislocations.

Pathology of Recent Dislocations.—The laceration of ligaments is determined by the mechanism of the joint and by the character of the ligaments. In the arthrodial joints the injury to the capsule may only be on one side, but in the hinge joints the ligaments are likely to be ruptured upon both sides of the articulation. The ligaments may be stretched in some joints, so as to give complete displacement without laceration, notably in the dislocation of the lower jaw. The muscles are occasionally ruptured and the vessels and nerves compressed or lacerated, though the blood-vessels are rarely seriously injured. Bony prominences may be detached, as in the coronoid process of the ulna. The margins of the articular surfaces may be broken off, as the rim of the acetabulum. The *tearing away of an apophysis* may occur as a complication of a dislocation. These fractures of the bone are not apt to be extensive enough in dislocations to make special complications, though occasionally a complete break occurs. The dislocation may be *compound*—that is, the injury to the soft parts may expose the joint.

The special pathology of unreduced dislocations is found in the change in the relations of the parts about the articular surfaces and in the changes which follow the pressure of the bone upon the contiguous tissues. The displaced bone becomes attached to the adjacent tissues. A new socket is formed of the soft parts, against which it presses or at its point of bony contact. If the capsule of the joint be stretched over the joint surface, it may become adherent to it and practically limit the formative processes and changes about the joint. The muscles and nerves may become adherent to the displaced bones and undergo *atrophy* or *degeneration*. The viscera are rarely injured by dislocations, except in those that involve the vertebræ. Injury of the pelvic viscera is possible in dislocations of the femur where it penetrates the acetabulum and

enters the pelvis. The displaced clavicle also may injure the vessels of the neck.

If the reduction of the dislocation is promptly made, it is generally followed by repair and the function of the joint is restored, though limitation of free movement may exist and is especially apt to accompany undue inflammatory reaction. A good recovery follows even the compound dislocation if suppuration is avoided. The imperfect repair of the capsule of the joint or of the ligaments may lead to a condition which admits of a ready displacement of the bone. Frequent recurrence constitutes what is called recurrent or habitual dislocation. Injuries of nerves by laceration are frequent. An injury to the nerves may express itself by a loss of power in the muscles or by loss of sensation. Involvement of the nerves may occur from a neuritis, and be dependent rather upon contusion of the small nerves than upon direct injury to the nerve-trunk itself.

Symptoms of a Dislocation.

The symptoms of a dislocation are clear and well defined, but the possibility of the existence of a fracture, and the swelling that occurs about a deeply situated joint, not infrequently make the diagnosis difficult. The general symptoms are—(1) *Deformity*, evident in contour and in the fixed position of the distal bone. (2) *Pain* about the joint, usually quite severe: as nerve-trunks are frequently subjected to pressure, this pain may extend to the points of distribution of nerve-fibres. (3) *Voluntary movements* are very much *limited*, and there is a *rigidity* of the injured parts which resists passive movements, except when laceration of the ligaments and capsule is extensive. (4) The normal *outline of the region about the joint is changed*, and bony landmarks indicate the altered relation of the bone. (5) The dislocated bone can often be *outlined in its new position*, and the injured extremity may be lengthened. (6) The *direction of the axis of the dislocated bone is altered.*

The DIFFERENTIAL DIAGNOSIS BETWEEN FRACTURE AND DISLOCATION is determined by the elastic fixation of a dislocation, the absence of crepitus, and the fact that there is but little tendency to redisplacement in a dislocation. Each one of these symptoms may, however, be reversed. Mobility and redisplacement may characterize a dislocation where extensive injury to the soft parts is inflicted. Crepitus may be present when an apophysis is detached or when a prominence of bone on the margin of the articular surface is broken.

Treatment.

The anatomy of the joint determines the nature of the efforts to be made for the reduction of the dislocation. Anatomical knowledge in manipulation must be relied upon in accomplishing the reduction rather than the application of sheer force to the dislocated bone. The reduction by special manipulation is to be effected often through the integrity of special ligaments, which, if destroyed, make systematic movements useless in securing the adjustment. Reduction by the force of extension and counter-extension overcomes muscular resistance and pulls the displaced bone over bony points of resistance, but it may lacerate the capsule and contiguous tissue and injure nerves and blood-vessels. The capsule heals, ligaments reunite, and the injury to the soft parts is soon repaired in simple dislocations if reduction is promptly made. The synovitis, usually slight, soon subsides, and the repair is fairly complete in a few weeks. If undue inflammatory action should occur, it is apt to result in some loss of function by reason of agglutination of the parts.

Laceration of nerve-trunks may result in permanent injury, and muscles that are torn may be so imperfectly restored that weakness of the joint continues. Compound dislocations with fracture may result in acute suppurative inflammation, leading to loss of function.

Rest is essential to perfect restoration of the joint, and even if the primary disturbances have subsided, the joint should not be subjected to excessive motion in any direction until the parts have become thoroughly restored. The injured joint should be kept at rest from three weeks to three months. The acute inflammatory process is to be controlled by heat or cold and rest.

Dislocations remain unreduced by reason of ignorance, inattention, the interposition of muscles or tendons, a small opening in the capsule, or because a fracture of some of the bony prominences permits the bone to escape easily after reduction. *Unreduced dislocations become irreducible* after a period of time that varies with the anatomy of the joint and the degree of reaction that attended the injury. Adhesions form which make violent efforts at reduction dangerous. The limit of time when it is injudicious to make efforts at reduction cannot be said to be fixed. This is especially true since *arthrotomy* has become a comparatively safe operation in the reduction of these ancient dislocations. The *nearthrosis*, or new joint formed by the displaced bone, may often become so perfect as to make it undesirable to attempt reduction by operative means. Reduction with good restoration of function is often possible after the lapse of a long time. The time at which this is possible and advisable is greater in the ball-and-socket joints than in the hinge joints.

Compound Dislocations.—This complication is infrequent, for the violence necessary to produce protrusion of the articular surfaces is necessarily great. The consequent injury to the surrounding tissues, including vessels and nerves, is serious and is apt to result in suppuration. The gravity of the condition varies, however, very greatly in different joints, the difference being found rather in the amount of injury to the contiguous tissues from the violence necessary to make it compound than to the special characteristics of the joint. It is an especially grave complication in the hip. The opening in the compound dislocation of the shoulder is usually in the axilla, and constitutes a serious lesion. Fortunately, it is a rare injury in these joints. It is much more frequent in the ankle, the elbow, the knee, and in the dislocation of the phalanges or the metacarpal bone of the thumb. Special effort must be made to attain a perfect aseptic condition. Good drainage must be secured in selected cases by gauze packing.

SPECIAL DISLOCATIONS.

Simple dislocations of the lower jaw present only two forms—the *unilateral* and the *bilateral with forward displacement.* The double or bilateral is the most frequent. This injury is more frequent in women than in men. It is rare in children and in the aged. A dislocation backward and outward may occur, but it is as a complication of a fracture of the glenoid fossa or of the jaw, and is the lesser of the two injuries.

The mechanism of the anterior dislocation, whether of one or both sides, is the same. It occurs when the mouth is widely open by the condyle slipping forward over the eminentia articularis. It is aided in this escape from the glenoid fossa by the external pterygoid muscles. The temporal muscle is made tense and firm, and helps to retain the bone in the abnormal position. The capsule is not necessarily torn. The interarticular fibro-cartilage is carried forward with the condyle (Fig. 341).

FIG. 341.

Double forward dislocation of the inferior maxilla.

The SYMPTOMS are the rigidity of the jaw with inability to close the mouth, a projection of the chin, and the presence of the condyle forward of its normal position. A deviation of the jaw toward the uninjured side is present in the unilateral dislocation.

TREATMENT.—Reduction is effected by depressing the angle of the jaw, the symphyses being at the same time supported, the object of the movement being to pull the condyle downward until it can be carried backward over the articular eminence and forced into the glenoid fossa. The joint should be put at rest for two weeks at least.

The Sternum.—The dislocation of the body of the sternum from the manubrium and the xyphoid appendix from the body are the usual displacements. The dislocation of the body from the manubrium is produced by muscular action, by strong flexion of the head and body, by direct violence applied to the body, or by forced dorsal flexion. In displacement produced by flexion or muscular action the displacement of the body is usually forward. It may be displaced backward by direct violence.

The PATHOLOGY and TREATMENT are the same as in fractures. Bony union occurs between the different pieces of the sternum at about the thirty-fourth year. (For dislocation of the ensiform cartilage, which is rare, see Fractures.)

Dislocations of the Ribs.—Clinical records prove the possibility of a dislocation of a rib from the vertebræ. The dislocation is forward. This injury appears to involve the eleventh and twelfth ribs more often than the others. The chondral cartilage may be displaced from the ribs and from the sternum. These injuries are rare, and are to be treated as fractures.

The Clavicle.—Both ends of the clavicle may be displaced simultaneously, but more frequently only *one end* is dislocated. The *sternal end* is dislocated *forward*, *backward*, and *upward*. The forward dislocation is produced by forcibly carrying the shoulder backward and downward. The sternal end is lifted from its articulation, and when the shoulder is freed from its restraint the end of the clavicle is carried forward on to the sternum. The dislocated head is easily recognized by palpation, local pain is present, the shoulder is depressed, and the function of the arm is impaired. Dislocation *backward* is produced by direct violence forcing the bone into its new position, or by indirect vio-

lence, when the shoulder is forced forward and inward. The bone can be felt in its new position, and the direction of the axis of the bone shows that it is displaced backward. The *upward* dislocation occurs when the shoulder is forcibly depressed. The end of the bone is then found above the sternum. The backward and the upward dislocations may disturb respiration, and the backward displacement may also interfere with deglutition.

These dislocations are *reduced* by carrying the shoulder upward, outward, and backward, and by direct manipulation of the displaced end. The great difficulty is found in maintaining reduction, for it is difficult to hold the shoulder in a fixed and proper position. Direct pressure on the end of the clavicle may aid in keeping it in position. The bone should be frequently inspected, for the inclination of the articular surfaces favors redisplacement, and treatment must be continued for several weeks. The arm should be used with caution for two months.

The *acromial end* is rarely displaced except in an *upward* direction. This *supra-acromial* displacement is caused by a blow upon the shoulder or by a fall. It does not often overlap the acromion.

The SYMPTOMS are impaired function of the arm, prominence of the end of the clavicle, and easy reduction and recurrence of the dislocation.

Stimson's plan of TREATMENT is very good. A broad strip of plaster is used. The middle of the band is placed under the elbow; the ends are carried up the arm and over the shoulder so that they cross over the displaced end. A firm pad may be placed between the plaster strip and the end of the clavicle. Moore's dressing for fractured clavicle (*q. v.*) is also an excellent dressing.

Total dislocation of this bone occurs from extreme violence, which pushes the shoulder inward, displacing the sternal end forward and the scapular end upward.

TREATMENT is directed to keeping the bone in position by carrying the shoulder outward and backward and by direct pressure upon the bone. The result in dislocation of either end of the clavicle is usually good, and, though perfect retention of the displaced extremity is not feasible except by operative measures, its function is generally not impaired by the remaining deformity.

Dislocation of the Shoulder-joint.—The bony part of the shoulder-joint consists of the glenoid cavity and the head of the humerus. The articular surface of the glenoid cavity is oval in shape, with the small end pointing upward and forward, and is quite small in comparison with the head of the humerus. It serves merely as a point of support for the humerus in its movements. The head of the humerus is hemispherical in shape, is placed obliquely on the shaft so as to form an angle of about 140° to its axis, has a diameter of about two inches, and an articular surface three or four times as great as that of the glenoid cavity, although the articular surface of the cavity and the support it gives to the humerus in its movements are increased by a fibro-cartilaginous ring which is attached to its margin. The capsular ligament completely encircles the articulation, is attached beyond the glenoid cavity, and is remarkably loose, being much longer and larger than is necessary to keep the bones in position. The looseness of the capsule permits the bones to be separated from each other for an inch or more, and secures to the joint a

gliding as well as a rolling motion. The capsule is also remarkably thin, so that the articular surfaces are readily displaced on the application of moderate violence.

The prominence of the shoulder, the many functions of the arm, and its freedom of motion, the comparatively small size of the glenoid cavity, and the laxity of the capsular ligament so expose the shoulder-joint to dislocation that more than half of all dislocations are of this joint. It is worthy of note that these dislocations almost never occur in children, are rare in the aged, and are three or four times more frequent in men than in women. The humerus is held firmly in position when at rest by atmospheric pressure ; when it is in motion the action and counter-action of the various muscles attached about and passing over the joint strengthen the capsule greatly and prevent dislocations resulting from normal movements.

The shoulder-joint being without bony protection in the greater part of its circumference, admits of a number of different dislocations. Keeping the glenoid cavity as a central point from which to designate these displacements, they may be spoken of in the order of their frequency as *anterior*, *downward*, *posterior*, and *upward*.

Indirect violence is the most frequent cause of the dislocation : this may be by leverage, the head of the bone being lifted out of the socket by strong rotation, by abduction or adduction; or the head of the bone may be pushed through the capsule by a fall upon the hand or elbow. The position of the arm and direction of the force determine the particular form of dislocation that occurs. The humerus may also be dislocated by muscular action and by direct violence.

Fig. 342.

An old unreduced subcoracoid dislocation.

It is said that in some cases a dislocation of the humerus occurs without laceration of the capsular ligament, but these cases must be very rare indeed, the rule being that the capsule is torn and the head protrudes through the opening. The capsule is not only thicker above than below, but it is reinforced from above by the coraco-humeral ligament, so that the rent occurs generally in the lower part of its circumference, either anteriorly or posteriorly, depending upon the direction of the displacement: unless the displacement is considerable, the muscles are not torn from their insertions to any great extent, though there is some laceration of them in all primary complete dislocations. The axillary nerves and vessels may be pressed upon or lacerated by the displaced bone, but generally they escape serious injury.

In the *anterior* or *subcoracoid dislocations* the head of the bone escapes through a rupture in the anterior and lower part of the capsule, and pushes forward before it the subscapular muscle or ruptures its fibres. The margin of the head or the anatomical neck rests against the margin of the glenoid cavity, and the head is under the coracoid process. If the bone is carried farther forward by the violence, more of the capsule is

torn, the greater tuberosity may be torn from the bone, and the head finally rests to the inside of the coracoid process, and it becomes a *subclavicular* dislocation. The posterior portion of the capsule is stretched tightly over the glenoid cavity or is lacerated. The tendon of the biceps is sometimes torn from its groove. The *downward* or *subglenoid dislocation* occurs when the rupture in the capsule is at a lower point, and is apt to follow in cases where the elevation of the arm was very great when the violence was inflicted. The head of the bone escapes below the subscapular muscle, and rests against the border of the scapula rather on its ventral surface. The axillary vessels and nerves are more likely to be disturbed by pressure in this variety. The external rotators are more certainly ruptured or the tuberosity detached when the head is thus displaced.

The *posterior, subspinous, dislocation* is more rare. It occurs when the arm is adducted and the elbow raised somewhat. The head of the bone passes backward under the spine or is arrested under the anterior extremity of the acromion process.

The SIGNS AND SYMPTOMS of a dislocation of the shoulder are—*pain* in the region, *flattening* of the shoulder, *prominence* of the acromion (Fig. 343), with a *depression at the glenoid cavity* and *lengthening* of the

FIG. 343.

Exhibits a subcoracoid dislocation and the position of the patient in his endeavor to find relief from pain.

arm in the forward, downward, and backward displacements. A shortening of the arm occurs in the upward displacement.

A change in the *direction of the axis of the humerus*, *inability to bring the elbow to the side*, *loss of voluntary motion*, with an elastic resistance to passive motion, and the presence of the head of the humerus in the new position, aid in the DIAGNOSIS. The elbow is not easily carried inward or forward on the chest, and the *hand cannot be placed on the opposite shoulder* while the elbow touches the thorax (Dugas).

The *differential diagnosis* between a fracture and a dislocation at the shoulder depends upon the character of the deformity, the increased ease with which passive motion can be made in a fracture, the resistance met with in a dislocation, and the ease with which extension and counter-extension reduce a fracture, unless it be an epiphyseal separation, while the dislocation requires certain well-regulated systematic movements to accomplish its reduction. The great readiness with

which the deformity in a fracture recurs, and the presence of bone-crepitus in the fracture, which is not present in a dislocation unless there be also a fracture about the point. The fracture which most closely simulates a dislocation of the shoulder is that of the neck of the scapula, but the mobility of the part, the ease with which the deformity can be reduced, and the immediate recurrence of the deformity in the fracture should not make the diagnosis very difficult. The diagnosis of the particular form of dislocation is determined by the position and direction of the shaft and the location of the head of the humerus. The lengthening of the arm is greatest in the downward, less in the subcoracoid, and least in the backward dislocation. It is short in the upward dislocation. The elbow is carried farther from the side in the downward displacement. The elbow is carried outward and backward in the anterior and subglenoid dislocation, but it is forward in the subspinous. Outward rotation is generally present in the subcoracoid and the subglenoid dislocations, while inward rotation is found in the subspinous.

The TREATMENT of a dislocation at the shoulder should be the early reduction of the deformity and the adjustment of the joint surfaces. An attempt should be made to do this without an anæsthetic. If this effort be ineffectual, then an anæsthetic must be given in order to overcome the muscular resistance incident to the new position and the irritation of the injury. Opposition to reduction may also be found in the difficulty experienced in freeing the head of the bone from the border of the glenoid cavity, in the small opening in the capsule, in the intervention of portions of the freely torn capsule, and in the peculiar relations of the subscapular muscle and the biceps tendon.

It is easier to reduce a dislocation immediately after the injury than it is at a later date. After a time, varying from a few days to a year or more, it becomes impossible to accomplish the reduction by manipulation, an operation then being necessary. When the replacement occurs the bones can be felt in their normal relations, and the resistance to active and passive motion disappears; sometimes an audible snap is produced by the joint surfaces coming quickly in contact with each other.

In attempting to reduce the dislocation the arm should be first carried in those directions in which it meets with least resistance. When force is to be used, we must be guided in the application of it by our knowledge of the anatomy and physiology of the parts. The mechanism of the force necessary to be applied in order to reduce a dislocated humerus varies in the different dislocations and depends upon the form and extent of the displacement. *Extension and counter-extension* are, however, constant factors in all of them. In addition to the extending force, the desire is to use rotation and leverage in such a way as to limit the power necessary to be expended.

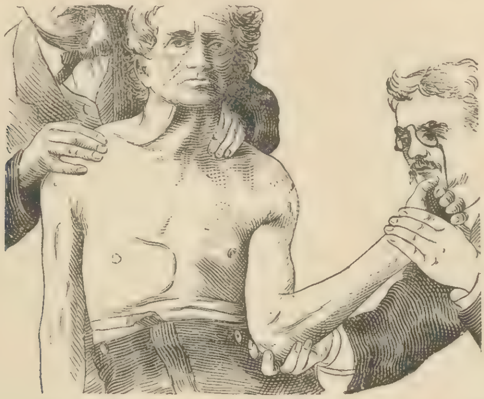
FIG. 344.

First position in Kocher's rotation method.

The *anterior* dislocations are by far the most frequent, and of these the subcoracoid makes a very large proportion, so that the manipulation necessary to reduce this form of dislocation has received the most attention at the hands of surgeons.

Quite a number of methods have been described, but the most efficient of them perhaps is the one known as *Kocher's rotation method*, which is used in the following way: The elbow is carried firmly to the side, with the forearm at a right angle to the arm, and the arm is then forcibly rotated outward till the forearm points away from the body (Fig. 344). When this has been done the arm is carried up from the body till it is

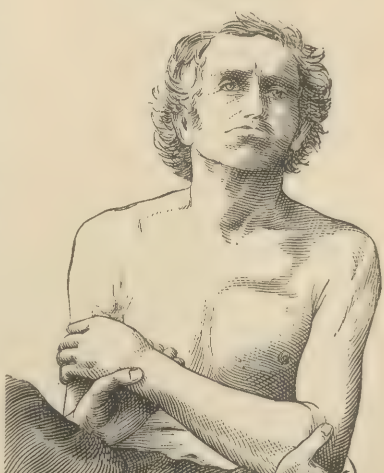
FIG. 345.



Arm is being carried forward and upward toward second position.

in the horizontal plane running through the glenoid cavity. The scapula is fixed and firm extension is made during these movements (Figs. 345, 346). When the arm comes to the level of the shoulder, it is gradually rotated inward, and is again brought to the side with the forearm across the body. The head slips into place with the inward rotation and at the beginning of the downward movement. This method requires care in its use, especially in the aged, in order to avoid fracturing the bone in the effort to replace it, for the bone is under the strain of torsion.

FIG. 346.



Completion of third movement in Kocher's method.

Although use is made of leverage in all of the methods of reduction, there is a manipulation which is called the *lever method*, which was preferred by Sir Astley Cooper. It is as follows: With the patient sitting on a chair, the surgeon stands behind him and lifts the arm of the injured shoulder from the body till he can get his knee in the axilla, resting his foot on the chair on which the patient sits. He now fixes the acromion with one hand and grasps the arm above the elbow with the other, using the humerus as a lever, and the knee in the axilla as a fulcrum. When the head is brought near to a point of reduction, the knee is elevated by raising the foot on the toes, the head of the humerus being thus raised still higher. Extension is kept up during the whole

of the procedure, and by moving the humerus with the hand and knee alternately the head is gradually brought into position.

The method by perpendicular extension, first used by Mothe in 1812, was for a time very generally used. It is applied in the following way: With the patient sitting upon a low chair or on the floor, a folded towel is put over the shoulder and is firmly held by an assistant in order to fix the scapula. Another assistant sits on the well side and pulls firmly on a second towel which passes under the injured shoulder. The surgeon now stands on a chair or table and grasps the arm at the elbow, and makes firm perpendicular extension upon it till the head is brought into position. The arm is then brought cautiously to the side and held in a sling.

Various devices employing pulleys in making horizontal extension have been used and highly recommended, but they are rarely used except in the attempt to reduce long-standing dislocations. Since aseptic surgery has made the operation of arthrotomy practicable they are becoming less and less applicable.

The impulsion method of Avicenna possesses at least the negative merit of not offering the possibility of doing further injury to the parts, and, although it is not generally successful, it should be practised, for it is the only manipulative method we can apply in those dislocations in which there is also a fracture of the neck of the humerus, and it is sometimes successful in the complicated subcoracoid and axillary dislocations. It is as follows: The patient sits on a chair and the surgeon stands behind and a little to the injured side of him. The surgeon now fixes the acromion with the hand next his patient, and with his other forearm supports the arm of the patient at such an angle as may suit the stage of the manipulation, while pressing with the same hand the head of the humerus toward the glenoid fossa.

In the *axillary dislocation* abduction, extension, outward rotation, and finally adduction, accomplish the reduction. Upward traction is here a valuable aid.

The *subspinous dislocation* is replaced by raising the arm to a level with the shoulder, making extension in a forward direction, rotating the arm outward, and then bringing it to the side while direct pressure is made upon the head from behind. The upward dislocation is reduced by downward and outward extension.

On analyzing the different methods which we have given, it is evident that they depend upon extension and counter-extension, rotation and leverage. In view of this fact, and inasmuch as that method which utilizes these forces in the simplest and most effective way and adapts itself to the greatest variety of cases is of the greatest value, it seems to me that the following method is good: The patient lies on his back on the floor or on a table. The operator, removing his shoe, puts his heel in the axilla or the foot against the ribs or the top of the shoulder, and, grasping the forearm and elbow with his hands, makes use of extension, counter-extension, rotation, and leverage in such a way as the character of the injury and the stage of the manipulation may suggest. Strong extension by an assistant can be made during manipulation by putting a clove hitch about the arm with a towel or sheet. This may also enable the surgeon, by looping the sheet about his loins, to make extension upward, outward, or downward. Downward traction with the heel in the axilla is to be made in the subcoracoid dislocations. Outward traction with the foot against the ribs is used to advantage in the subclavicular dislocations.

Upward traction in the subglenoid dislocation with the foot on the acromion to steady the scapula is generally successful, but is more dangerous than the downward pull with direct pressure on the head with the heel or hands. The movement, under traction, of the arm downward

and forward to the chest, with inward rotation, terminates the effort. In the subspinous dislocation forward traction with rotation usually determines reduction. This combines extension and counter-extension with the rotation method and the lever method of Sir Astley Cooper. It is a very efficient method, and is to be recommended on this account, as well as on account of its simplicity and versatility.

A sling which should embrace the forearm and give support to the elbow should be adjusted after the dislocation has been reduced. This gives sufficient immobility to the joint, which should be kept at rest for *three* weeks. Moderate use may then be made of the joints, but extreme movements should not be permitted. Special complications involving excessive reaction may require topical applications. The complicated cases are to be treated in accordance with general surgical principles.

When a fracture and a dislocation exist together, an attempt is made to reduce the dislocation by the Avicenna impulsion method. If this fails, the parts should be cut down upon and the head replaced, and the fragments secured in position, if necessary, by sutures. The displaced fragment, if unreduced and if it be only the head and surgical neck, may be removed, or a nearthrosis may be permitted to form between the fragment and the shaft by separating them from each other by extension. The old rule, of first permitting the fracture to unite and then attempting to reduce the dislocation, has lost its favor since aseptic conditions make operations so promising. The injuries to nerves and vessels must be treated according to general surgical rules.

The PROGNOSIS in a simple primary dislocation when reduced soon after the injury is good. The longer the dislocation has existed, the more unfavorable the prognosis. In the cases which are compound or accompanied by fracture or injury to the nerves or vessels the prognosis is unfavorable in proportion to the amount of injury done and the degree of inflammation following it. After a dislocation has occurred the resistance to the force tending to produce it again is less than it was originally. In some cases this leads to frequent repetitions of the dislocation, and these are called cases of habitual dislocation. These cases of habitual dislocation may be operated upon by excising a part of the capsule if it be excessive, or by suturing the rent if that be the source of trouble. The most frequent cause of the habitual dislocations at the shoulder is the tearing loose of the supra- and infraspinatus muscles from their attachment to the greater tuberosity, or the detachment of a fragment of the tuberosity from the head of the bone. In some of these cases bandaging the shoulder so as to prevent extreme movements of the arm may be tried before operative measures are resorted to.

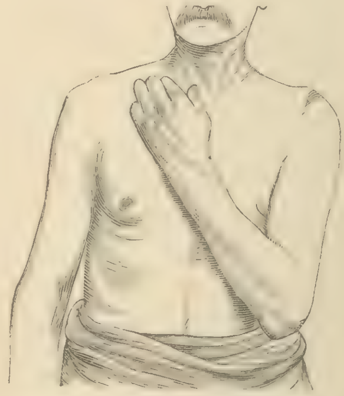
The exact period of time after which it is impossible to reduce a dislocation of the humerus by manipulation cannot be given, for it depends upon the extent of the injury to the soft parts, the degree of fixation of the bone in the new position, the extent of the displacement from the normal position, and the degree of change in the size of the glenoid cavity. In old cases, up to an age of a year or more, one should, under an anæsthetic, attempt to break up the adhesions, and by any of the methods of manipulation above described endeavor to replace the bone. If this effort prove fruitless and the function of the arm be greatly impaired by its position or from pressure on nerves or vessels, a *resection* should be made, unless the glenoid cavity is but little altered and the head can be brought (Figs. 347, 348) into position by a simple *arthrotomy.*

The relative results obtained by resection and arthrotomy are not clearly defined. Franz Smith has reported 32 cases of resection in old dislocation from Wolfner's clinic. In 20 cases (62 per cent.) a good result was obtained, while with arthrotomy only a moderately good result was

Fig. 347.

Old subcoracoid dislocation.

Fig. 348.



Reduced by posterior arthrotomy.

obtained in 33 per cent. of the cases. From this he concludes that resection is a better operation than arthrotomy in these cases.

Dislocations of the Elbow.—The elbow-joint, though its bony outline is so arranged that the articular surfaces are snugly and firmly opposed, is frequently dislocated. It is especially the dislocation of *childhood. Both bones may be dislocated in any direction*, and the end of either bone may be separately displaced, so that there are many forms of injury to this joint. The normal outline of the joint is distinct and the bony landmarks are clear and well defined, yet when swelling and tumefaction are present it is often difficult to diagnosticate the definite injury to the joint.

The most common dislocation of this joint is of *both bones backward.* It results from a fall upon the outstretched arm, the violence being transmitted from the palm of the hand through the forearm, which determines a hyperextension with rupture of the anterior ligament. If the bones are arrested at a point where the coronoid rests against the articular surface of the humerus, it is regarded as an *incomplete* dislocation, but if the coronoid be carried backward until it rests in the olecranon fossa, it is *complete.* Torsion of the forearm when in a position of semiflexion is also given as a method of producing this dislocation. The lateral ligaments are torn or detached from the bone.

Symptoms.—The elbow is partly flexed and the outlines are obscured by swelling. The olecranon has lost its proper relation to the external and internal epicondyles; the head of the radius may be identified, especially if the bones are also displaced outward, by rotating the forearm. The deformity upon the posterior aspect of the joint is more marked during flexion than in extension. The trochlear surface of the humerus can often be clearly outlined at the elbow in the extended arm.

Treatment.—Reduction is, as a rule, easily accomplished without

anæsthesia. Traction upon the extended or hyperextended arm should be made, and the forearm must then be moved to the right-angled position during the continuance of traction, with downward pressure on the forearm. This pressure may be secured by the hand of the surgeon or by the knee placed in the fold of the joint.

The arm should be carried in a sling for three weeks or placed in a fixed dressing. Passive motion should not be used until repair is fairly complete. In old dislocations it is necessary to break up adhesions by forced flexion and extension or by lateral movements before the displaced bones can be forced into position. Anæsthesia is essential in these cases.

Lateral displacements of both bones may be either outward or inward, and generally constitutes an incomplete dislocation. The lateral dislocations result from falls upon the extended arm. In *outward* dislocations the ulna rests against the articular surface of the humerus, and in *inward* displacements the head of the radius is in contact with the trochlear surface. Complete outward or inward dislocations are rare.

SYMPTOMS.—The width of the joint is markedly increased. The lateral projections of the humerus and those of the ulna or the radius are distinct. The motions of flexion and extension are painful; the forearm is slightly flexed, and the axis of the forearm is displaced to one side of its normal position or deviates from it so as to make an unnatural lateral angle. If these dislocations are complete, the symptoms are exaggerated.

Dislocations of the Ulna.—The only uncomplicated dislocation of the ulna alone is backward. It is very rare and is probably incomplete. The forearm is slightly flexed and adducted. The orbicular ligament is torn and the ulna and radius at the upper end are forcibly separated. The olecranon presents posteriorly, the head of the radius rotates in its normal position, and the forearm is inclined inward.

The TREATMENT of these lateral dislocations and that of the ulna are much the same. The reduction is accomplished by traction in the extended or semiflexed position, with lateral angling at the joint, while direct pressure pushes the parts into position. It may be necessary to force the ulna downward and backward away from the articular surface of the humerus before it can be forced into position.

Dislocation of both bones forward is exceedingly rare, and may be complicated by fracture of the olecranon. It occurs by a fall upon the elbow when the arm is in extreme flexion. It is complete when the olecranon is fully displaced in front of the humerus. The forearm is lengthened and fixed. The posterior surface of the humerus presses against the skin, the condyles are more prominent, and the olecranon fossa is empty.

Reduction is accomplished by extreme flexion and by pushing the forearm back into position.

Dislocation of the Radius.—The head of the bone may be displaced *forward*, *backward*, or *outward*. The first form is not infrequent, the latter very rare. The anterior and posterior dislocation may be produced by direct violence forcing the bone into its new position. The forward dislocation may be produced by hyperextension in a fall upon the pronated hand. The head of the bone slips forward in front of the capitellum. The orbicular ligament is torn or encircles the neck, the

head being above or beyond it. The arm is slightly abducted, partly flexed, and pronated. The swelling is in front of the elbow; the head can be felt in its new position, and there is a depression at its normal situation; movements are painful. In some cases the entire bone shows a displacement upward.

Reduction is accomplished by traction in the extended position with the forearm in forced supination. Direct pressure upon the head of the radius helps to force the bone into its natural position. In some cases there is a marked tendency to redisplacement; hence the treatment should be such as to keep the arm flexed and in supination until the rent in the capsule and the torn ligaments are reunited and firm. This may be done by a plaster splint or by a right-angled posterior splint.

The *backward* dislocation has much the same pathology. The rent in the capsule is behind. The orbicular ligament is torn. The head of the bone can be more distinctly felt and outlined in its new position. The position of the arm is much the same as in forward dislocation. The violence may be direct or by a fall upon the supinated and partially extended arm.

Reduction is by traction in an extended position with direct pressure on the head. The arm should be flexed at right angles and carried in a sling after reduction.

The *outward* dislocation is rare. It is difficult to retain it in position after reduction. The dislocations forward and backward, if they are also outward, are more difficult to maintain in proper position than if displaced directly in front or behind.

Dislocation of the Head of the Radius in Children.—A displacement of the head of the radius in children under five years of age is a recognized injury. Unquestionably, a peculiar injury at this part is found in children. It is produced by a firm pull upon the wrist or forearm, as in lifting or jerking the child by the arm. Pronation is thought to be present when the injury is inflicted. It is probable that the head of the bone is pulled out of the orbicular ligament and is displaced forward. The forearm is very slightly flexed; movements of the elbow are fairly free, except that supination of the forearm meets with resistance.

The displacement is *rectified* by *forced supination, with extension and traction.* An epiphyseal separation of the head may simulate this injury. This demands a few days' rest in a splint, with the arm flexed and strongly supinated, though a good recovery often occurs without any definite restraint.

The Wrist.

Dislocations of the wrist-joint are rare. The *backward* dislocation is more frequent than the *anterior.* It is produced by a fall upon the palm of the hand, and the deformity simulates that produced by a Colles fracture. The deformity is, however, greater, and the abrupt line of the carpus can be somewhat distinctly outlined at the projection on the dorsal surface. The sharp outline of the radius and ulna, anteriorly, is obscured by the mass of flexor tendons. The normal relations of the styloid process of the radius and ulna are, however, preserved and constitute a very important diagnostic sign.

The *forward* dislocation must be extremely rare. It usually results from a fall upon the palm of the hand with the hand in full dorsal flexion, but it also follows a fall upon the back of the hand.

The SYMPTOMS are the reverse of those that indicate a backward displacement. The projection in front presents its sharp angle at its upper border, and the articular extremity of the radius and ulna can be clearly outlined on the dorsum.

Reduction in these cases is accomplished by extension with firm pressure on the displaced carpus. The hand should be retained on a splint for two or three weeks. The joint should be kept at rest until repair is complete. The fingers should be free from restraint after a few days, for it is important to avoid adhesion of the tendons to their sheaths.

Dislocation at the Lower Radio-ulnar Joint.—The ulna is dislocated forward or backward in its relation to the radius. The backward dislocation is produced by exaggerated pronation of the wrist. This may be produced either by muscular action or by forced pronation. The *forward* dislocation is usually by direct violence.

The *reduction* of these dislocations is not difficult. The hand and arm should be retained on a splint for several weeks, and only a moderate use of the joint permitted until the parts have regained full strength.

The Carpus.—The *os magnum* is the only one of the carpal bones likely to be displaced. This bone is occasionally displaced *backward*, so that it is prominent on the dorsum. The bones of the carpus are closely bound together and are not often displaced, though a few cases of dislocation of the second row from the first are reported. This injury is usually an accompaniment of a crushing injury which breaks the bones and lacerates the soft tissues.

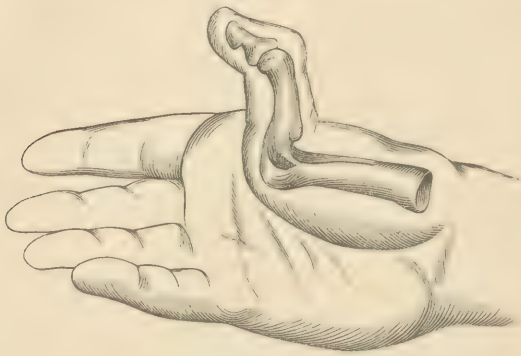
Carpo-metacarpal Dislocations.—The thumb is most frequently displaced. It is usually a backward displacement, and results from extreme flexion or direct palmar pressure. Reduction is not difficult, and is accomplished by traction and direct pressure.

Dislocation of the bone forward is usually by direct violence. The axis of the metacarpal bone in the *forward* dislocation is inclined inward and forward, but in the *backward* dislocation it is outward and backward. The base of the metacarpal bone is prominent in its new position. After reduction the hand should be kept at rest on a splint for three weeks. Dislocation of the other metacarpal bones is produced by a degree of violence which inflicts other important injuries.

Metacarpo-phalangeal Dislocations.—This joint in the thumb is not infrequently dislocated *backward*, less frequently *forward*. It is displaced *backward* by a fall upon the thumb bending it backward and pressing the base of the proximal phalanx on the dorsum of the metacarpal bone. The proximal phalanx is bent backward at a right angle and the distal phalanx is flexed. The capsule is ruptured and the lateral ligaments are probably torn. *Very great difficulty is sometimes experienced in reducing this dislocation.* It is sometimes easily reduced, but the obstruction to reduction is very marked when the tendons of the short flexor of the thumb surround the head of the metacarpal bone. The lateral ligaments of the long flexor and the sesamoid bone may interfere with an easy and ready reduction. The surgeon may convert a comparatively simple dislocation into a complex one by flexing

or extending the phalanx before the base has been brought well forward on the head of the metacarpal by forced dorsal flexion. This complication is produced by the backward displacement of the sesamoid bone on to the head or dorsum of the metacarpal, and to the slipping of the

Fig. 349.

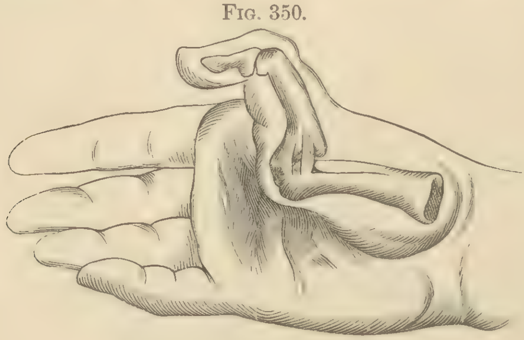


Metacarpo-phalangeal dislocation.

anterior portion of the capsule between the base of the phalanx and the head of the metacarpal (Figs. 349, 350).

Treatment.—The reduction is to be accomplished by forced dorsal flexion and pressure on the base of the phalanx. This movement is

Fig. 350.



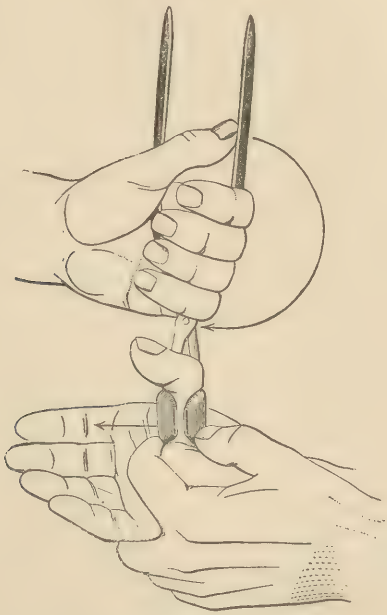
Metacarpo-phalangeal dislocation.

best executed when the metacarpal bone is flexed and when the phalanx is grasped in a pair of forceps or in Levis's instrument (Figs. 351, 352, 353). It should be clearly and distinctly understood that extension in a line parallel to the metacarpal bone is not admissible in the reduction of this dislocation.

An incomplete form of this dislocation can be voluntarily produced in many young people and loose-jointed individuals. The forward dislocation of this bone is produced by forced palmar flexion and pressure. The head of the metacarpal is prominent on the dorsum and the base of the phalanx can be felt in the lower part of the thenar eminence. It is easily reduced by forced palmar flexion and pressure upon the displaced bone. Backward dislocation of the proximal phalanges of the fingers is produced by forced dorsal flexion. They are more easily reduced and are not complicated by the divided short flexor tendons and the presence of sesamoid bones.

Dislocation of one or more of the second row of phalanges may occur. The injury is easily recognized, and can be reduced by traction and by direct pressure.

Fig. 351.



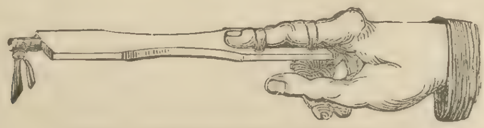
Farabœuf's instrument for reduction of dislocation of the thumb.

All of these injuries of the carpo- and metacarpo-phalangeal articulations need a rest of ten days or three weeks on a splint to secure a

Fig. 352.

Levis's instrument for making traction in reduction of dislocations of the phalanges.

Fig. 353.



Levis's instrument, faulty method of use.

good result. If reduction is impossible, then arthrotomy is demanded. This is rarely necessary even in the dislocation backward of the phalanx of the thumb.

The Hip.

Dislocations of the hip are much less frequent than those of the shoulder. They constitute about 5 per cent. of all dislocations. They are more frequent in men than in women, and are most frequent between the twentieth and fiftieth years, though the femur may be dislocated at any age. The normal limits of motion are more restricted than in the shoulder. This ball-and-socket joint is well guarded against dislocation by the deep acetabulum which embraces a large segment of the sphere of the head of the femur, supplemented as it is by the cartilaginous ring which acts in the retention of the head in the socket by increasing the suction traction. The strong ligaments, the muscles which surround it, and the protection obtained by the mass of tissue that envelops the joint guard it against injury.

The head escapes from the socket through a rent in the lower segment of the capsule, and may come to a rest at any point in the periphery of the acetabulum. The posterior dislocations occur during flexion, adduction, and inward rotation of the thigh. They are the most common of the dislocations. The anterior dislocations occur during abduction, often combined with outward rotation and extension. The head of the bone, emerging through the lower segment of the capsule, does not necessarily remain on the margin of the acetabulum at the point it first reaches, but it passes in the backward dislocation to a point of rest in the sciatic notch, or on to the dorsum of the ilium, or even upward to the anterior inferior spine of the ilium. If an anterior dislocation of the head of the bone exists, it may pass from the thyroid foramen downward to the perineum, or upward to become a pubic or an intrapelvic dislocation.

Each dislocation should in clinical work be classified as an *anterior* or *posterior* dislocation. The line of demarkation between these classes is drawn between the anterior superior spine of the ilium to the tuberosity of the ischium and crosses the acetabulum. The symptoms and the treatment of the anterior are much alike and contrast strongly with the posterior dislocations. These two comprehensive divisions are also known as *inward* and *outward* dislocations. The head escapes at some part of the lower two-thirds of the segment of the acetabulum, and is carried inward if the displacement occurs when the thigh is abducted, and outward if it is in a position of adduction.

According to prevalent classifications, we should *include in the anterior or inward dislocation* those on the *tuberosity* of the ischium, the *perineal*, the *obturator*, the *suprapubic*, the *ilio-pectineal*, and the *subspinous*. In the *posterior* or *outward* dislocations we should group the *ischiatic*, the *iliac*, the *everted dorsal*, and the *supracotyloid*. The classification made by Allis in his recent monograph is suggestive, simple, and comprehensive. He recognizes the fact that all forms of dislocations primarily escape from the lower segment, and when inward are first thyroid and then are shifted upward or downward. If the primary dislocation is outward, it is dorsal, and is then shifted upward or downward. Allis's classification is into—

(1) Lower thyroid. (2) Middle " (3) High "	All present the general characteristics of abduction and rotation outward.
(1) Low dorsal. (2) Middle " (3) High "	All present the general characteristics of adduction and rotation inward.

The integrity of the inverted Y-ligament (Fig. 354) is recognized as an important aid in guiding the dislocated head into a position of rest. The position in which the head is found gives a name to the dislocation.

The SYMPTOMS vary markedly with the different varieties of the inward and outward dislocations, as they also do in the outward or backward forms. There is, however, sufficient uniformity in the anatomy, the pathology, and the clinical symptoms of each of these two groups to justify us in making it a broad basis of classification.

The capsule of the joint is torn by the head of the bone as it escapes. If the rent in the capsule is made by simple abduction, it is apt to be less extensive than where rotation is the chief factor. In the latter instance the continued extreme rotation may increase the tear even after the head is already displaced. The inverted Y-ligament is, however, never torn entirely from its attachment to the femur. The posterior arm of this Y is occasionally lacerated. This ligament serves not only as a fulcrum for the leverage used in posterior dislocations, but it is the anatomical structure that limits the wandering of the head after the dislocation occurs. This iliofemoral ligament passes from the upper margin of the acetabulum to the anterior surface of the base of the neck. It does not envelop the head in any of the dislocations. It steadies the trochanter, and the more tense it is made, either by muscular contraction or by the rotation movements of the surgeon, the more strongly it keeps the head away from the socket; for when tense it holds the base of the neck against the margin of the acetabulum. This ligament must be considered in efforts at reduction. The torn portion of the capsule may overlap the socket and constitute an obstacle to reduction and a complication in healing. This is especially apt to be the case if the capsule is torn near its attachment to the femur.

FIG. 354.

Inverted Y-ligament.

Abduction and outward rotation are very constantly present in the anterior dislocations. Abduction may be very slight in the intrapelvic variety, and outward rotation may be very slight in the thyroid dislocation. The thyroid dislocation is the most frequent of the anterior dislocations. The limb is flexed and appears to be elongated, while the trochanteric region is flattened and the trochanter lowered and displaced inward. The adductors are usually tense, and the head can be felt in its new position. The impossibility of adducting the limb and forcing it to complete extension aids in the diagnosis. These symptoms are modified if the dislocation is above or below the thyroid foramen. If it passes high up in front toward the spine of the ilium, then an exception may occur and the symptoms be reversed and the leg be extended, everted, and slightly abducted.

Adduction and *inward rotation* are the cardinal signs of the *backward* or outward dislocations. When the head rests in the sciatic notch or on the dorsum of the ilium the limb is flexed. The trochanter is elevated

above Nélaton's line, and there is marked resistance to outward rotation, extension, or abduction.

These symptoms are distinctly modified if the head passes upward and inward until it is above the inferior anterior spine. Here the leg may be abducted, everted, and extended.

The DIFFERENTIAL DIAGNOSIS between the anterior and the backward dislocation is clear except in the subspinous (anterior) and the everted dorsal. In both the head is above the acetabulum. It is very essential to determine *to which class* the dislocation belongs before undertaking reduction. The symptoms in these two special dislocations may be much the same. Dr. Allis contends, with reason, that the trochanter cannot be to the inner side of the line drawn from the spine of the ilium to the tuberosity of the ischium in the dorsal dislocations.

FIG. 355.

Anterior dislocation of head of femur.

FIG. 356.

Posterior dislocation of head of femur.

MANIPULATION FOR REDUCTION.—It is a recognized fact that in every dislocation the head should retrace the path along which it passed during displacement. It should be remembered that in the dorsal dislocation the head escapes from the capsule in the lower posterior third of the margin of the acetabulum, and in the anterior dislocations it escapes from the lower anterior third. The head of the bone is to be brought to these points as a first step in reduction. It was plainly stated in the pathology of dislocations that strong rotation effected greater laceration during the escape of the head than when the head was lifted by leverage

through the capsule; so now strong rotation is a dangerous element in reduction. It must be carefully used when employed.

REDUCTION OF DORSAL DISLOCATIONS.—*Kocher's Method.*—The patient should lie on a folded blanket or mattress placed on the floor or on a table. The luxated thigh is rotated inward and flexed to a right angle. This brings the head to the acetabulum, and it is then lifted upward, the thigh rotated outward, and straightened as it is brought downward parallel with the other thigh. There is a purpose in each of these movements—viz. the inward rotation relaxes the capsule and ilio-femoral ligament, lifts the head from the posterior surface of the pelvis, and makes it movable. The subsequent flexion of the thigh to a right angle carries the head downward below the uninjured part and brings it opposite to the tear in the capsule. This is done without the application of force. One must be cautious in the forcible flexion, otherwise it may happen that the head will slip around the under margin of the socket and produce a forward dislocation into the obturator foramen. With the upward pull the ilio-femoral ligament and the capsule, chiefly at its upper posterior circumference, are put on the stretch as the head is lifted up to the border of the acetabulum, while with outward rotation, through the tension of the ilio-femoral ligament, the trochanter is fixed and the head is forced into the acetabulum by the parallel extension of the leg.

Middeldorpf's method of reducing posterior dislocations is the following: Strong flexion, abduction, and outward rotation of the extremity. The strong flexion lifts the head from the pelvis and brings it opposite to the tear in the capsule; abduction puts the ilio-femoral ligament on tension and brings the head to the margin of the acetabulum; and the outward rotation lifts the head into position. The leg is now extended parallel to the other.

The ease with which passive movements in all directions can be made and the snap of the joint surfaces coming in contact with each other in both methods prove that reduction has taken place. The inexperienced operator must be careful not to mistake an obturator luxation which he has produced by his manipulations for an anterior displacement or a reposition of the bone.

Allis's Method.—The patient lying supine, the surgeon kneels by his side, and if the right femur is dislocated he seizes the ankle with his right hand and places the bent elbow of his left arm beneath the popliteal space: (1) he now turns the bent leg outward (inward rotation) by means of the ankle and lifts upward (skyward); (2) then turns the bent leg inward (outward rotation) and brings the femur down in extension.

The following is *Kocher's method of reducing forward suprapubic dislocations:* The patient is placed on a table. Hyperextension is then made, and followed by flexion with simultaneous pressure upon the head of the thigh, and finally inward rotation.

The hyperextension, and perhaps with it some increased outward rotation and abduction of the leg, lifts the head from the pubis. In this movement we use the femur as a lever, the long arm of which is the shaft, the short arm the neck, and the greater trochanter the fulcrum. When the head is freed from the margin of the pubis, it is pressed with the hand downward and outward toward the acetabulum, so that during the relaxation of the ilio-femoral ligament and the necessary flexion it will not slip again to the pubis. The flexion is carried to the extent of a right angle, by which movement the capsule is made tense, and inward rotation now brings the head into the acetabulum.

Middeldorpf's method of reducing this dislocation is by hyperextension, strong flexion, adduction, and inward rotation. The hyperextension is done for the same purpose as in the previous method. The leg is flexed much more than in the previous method, amounting to an acute angle. By the flexion the head is moved down to the slanting surface of the margin of the acetabulum, and the movement of adduction which follows brings the head nearer into position, so that the inward rotation can complete the reposition. In both methods the patient lies on the margin of a table, so that there is no hindrance to the hyperextension.

The *forward infrapubic dislocation* of the thigh is reduced by Kocher by making flexion to a right angle, extension on the leg in this position, and strong outward rotation. The flexion of the thigh is necessary to relax the ilio-femoral ligament. Where the thigh is thus flexed to a right angle no part of it is on tension. We now want to use the capsule in the rotation, and we make a strong pull on the leg, so that it will be put on tension. The thigh is now turned outward as far as possible, extension being made on it during the rotation. The result is that the ilio-femoral ligament draws the head into position.

One reduces a perineal dislocation by *Middeldorpf's* method by flexing the thigh to a right angle, following this by adduction and inward rotation. The flexion in the given position of the leg relaxes the ilio-femoral ligament and makes the head free in its position. In order to prevent the following adduction from carrying the head around the acetabulum and producing an ischiatic dislocation, a folded towel is passed around the thigh at its upper extremity, and a strong pull upward is made upon it. The adduction brings the head to the margin of the acetabulum, and the inward rotation brings it into position.

The *downward* or *infracotyloid dislocation* is reduced by extension in the given position of the leg—that is, in a flexed and an abducted position and then rotating the leg outward.

The *upward* or *supracotyloid dislocation* is best reduced by a folded towel, and finally inward rotation completes the reduction.

Dr. Allis directs for replacement of the head in the anterior or inward dislocations—

1, Flex and abduct the femur; 2, make traction outward; 3, fix the head by digital pressure and adduct.

Dr. Allis strongly cautions the operator not to adduct until after he has made traction outward. He directs for reduction by means of external rotation—

First step, flex the thigh, but not to a perpendicular; second step, adduct, carrying the knee obliquely inward and downward; third step, rotate outward.

Reduction by Means of Rotation Inward.—*Bigelow* puts this manœuvre at the head of his ten rules. His directions are—"Flex the limb toward the perpendicular, and abduct a little to disengage it from the bone; then rotate the thigh strongly inward, adducting it and carrying the knee to the floor. The trochanter is then fixed by the Y-ligament and the obturator muscle, which serve as a fulcrum. While these are wound up and shortened by rotation the descending knee pries the head upward and outward to the socket."

Rule.—First step, flex the thigh, but not to a perpendicular; second step, rotate strongly inward; third step, adduct and carry knee to the floor.

All dislocations of the hip should be treated after reduction by rest and quiet. This is especially important in young subjects. The

Hodgen suspension splint for a few weeks is most comfortable and efficient.

The Patella.

A dislocation *outward* results occasionally from a violent muscular contraction of the quadriceps extensor muscle. The patella is then slipped over the articular surface of the external condyle. It may also be dislocated outward by a blow upon the inner border of the patella. These dislocations occur when the leg is extended. If *complete*, the internal border is directed forward and the articular surface is directed toward the middle line of the leg, and the margin of the patella is against the side of the condyle; but in the *incomplete* dislocation the rotation is reversed, and the outer border is inclined forward, while a part of the articular surface is still in contact with the articular surface of the external condyle.

Dislocations *inward* are very rare, and are always produced by direct violence. These dislocations are most likely to occur when the capsule is relaxed. Laceration of the capsule is generally present.

Reduction is effected by flexing the thigh strongly on the body, and by pressing firmly on the sharp projecting edge of the patella so as to rotate its articular surface toward that of the femur. The edge against the condyle is freed and the muscle pulls it into place.

Vertical rotation of the patella occurs from a blow when the leg is partly flexed. The rotation is usually outward, so that the articular facet looks inward.

Manipulation while the leg is fully extended may reduce the dislocation. It may also be reduced by sudden and forcible flexion. This manœuvre may increase the damage to the joint. The close investment of the displaced patella by a rent in the capsule may render incision necessary to effect its release and reduction.

These dislocations are painful and the disability is complete. Recovery is, however, prompt and good after moderate rest.

The Knee.

Traumatic *anterior* dislocations of the tibia are more frequent than the posterior dislocations. The *posterior* dislocation frequently results from pathological changes in the joint-tissues. The ligaments soften and muscular action determines the gradual pathological displacement. The *anterior* dislocation is produced by hyperextension or by a blow upon the anterior surface of the thigh or the posterior surface of the leg. It is more frequently incomplete than complete. The capsule and the lateral ligaments are ruptured in the complete form. The pressure of the condyles of the femur on the vessels in the popliteal space is a serious and frequent complication in this injury.

The leg is generally extended; slight rotary displacement of the tibia is present. In the complete form shortening is evident. The projection of the tibia in front of the condyle gives contour to this deformity.

Reduction is easily effected by traction and coaptation. Flexion may also be used in effecting reduction, but hyperextension is dangerous. Compound dislocations of the knee-joint should meet with conservative aseptic treatment unless the popliteal vessels are completely destroyed.

Dislocations *backward* are less frequent, and are produced by direct violence and also by indirect violence, as in cases where the leg is caught and held in a fixed position and the body pushed forward until the femur is carried forward by rupture of the capsule and partial or complete rupture of the lateral ligaments of the joint. Hyperextension is usually present. The contour of the condyle of the femur in front and of the tibia behind, with shortening in the complete form, indicates the diagnosis. The vessels are not so likely to be injured in this form as in the forward dislocation.

Traction with coaptation, and possibly flexion, will accomplish reduction.

Lateral dislocation of the knee may occur by forced lateral flexion. *Torsion* also enters as a factor in producing these dislocations. They are most frequently incomplete. The outward dislocation is most common.

The SYMPTOMS are found in the changed outline of the joint. The injury to the joint-tissues depends upon the extent of the displacement and the manner of production. Reduction is easy.

All of these dislocations at the knee require a prolonged rest of six weeks to four months. A plaster-of-Paris splint is best suited to these cases. Immediately after the injury it may be necessary to use local treatment to control the inflammatory process. A posterior splint or the Hodgen suspension splint should be temporarily used to keep the injured joint at rest.

The Semilunar Cartilages.—Dislocations of portions of the *semilunar cartilages* may occur. A fragment of the cartilage is displaced either toward the intercondyloid notch or it is displaced toward the periphery, so that it projects as a ridge at the border of the tibia. The explanations of its pathology are not full and complete.

The SYMPTOMS simulate those of a loose cartilage in the joint. It is produced by torsion and flexion of the joint. The most serious disability is exhibited when the cartilage is displaced into the joint. The loose section is not infrequently pulled into the joint during flexion, but is apt to appear again at the margin when the leg is straightened. If it is entangled in the joint, the disability is complete until it is again freed from its abnormal position. This can usually be acomplished by rotation, sudden flexion, and extension.

The symptoms vary. The cartilage may be outlined as a ridge along the border of the tibia, especially along the inner anterior border. A patient may be walking or kneeling and the luxated cartilage may be pulled into the joint. A sudden loss of function, with sharp pain and perhaps swelling of the joint, discloses the condition.

The only TREATMENT available is to put a limitation on the flexion of the joint or an operative procedure to fasten the cartilage to the head of the tibia. The result of the operation is said to be satisfactory.

The Fibula.

The upper end of the fibula has been displaced *forward* by forcible inward rotation of the foot while in full extension. The extensor muscles are supposed to have pulled it forward out of place. It is also dislocated *backward* by the forcible contraction of the biceps.

An *upward* dislocation may occur as a complication of fracture of the tibia or by an upward displacement at both ends. The displacements are easily reduced by pressure on the head of the bone with the foot at a right angle with the axis of the leg. It can be retained by pads and supports. The backward dislocation is more uncertain in stability of position after reduction. Rest in a fixed position should be enforced. The lower end is rarely dislocated or detached, except as a complication of fracture.

The Foot.

The dislocation may be *backward*, *forward*, or *inward*. The *outward* dislocations are associated with a Pott's fracture. The *backward* dislocation is produced by extreme plantar flexion. The lateral ligaments are torn and the capsule more or less fully lacerated, and a fracture of the external malleolus is often present. The foot appears shortened in front, the heel is lengthened. An incomplete backward dislocation is a frequent accompaniment of Pott's fracture. A *forward* dislocation is produced by extreme dorsal flexion with forward pressure on the heel. The astragalus can be outlined in front of the tibia. The *inward* dislocation of the foot is most frequently produced by supination and adduction of the foot. The *astragalus* has its external border displaced downward, and rests below and in front of the external malleolus. The external lateral ligament is torn, and the inner border of the astragalus is inclined upward against the tibia. The dislocation of the ankle is easily *reduced* by traction, pressure, and by dorsal or plantar flexion and by eversion of the foot. Rest in a plaster cast for a few weeks restores the foot and gives good functional activity.

The foot is sometimes dislocated from the astragulus. The displacement is *backward and inward* or *backward and outward.* It is exceedingly rare to have an *anterior* displacement. The backward dislocations are incomplete, for the articular surface of the astragalus remains in contact with some portion of the surface of the calcaneum. The head of the astragalus is on the dorsum of the scaphoid, or, if the backward displacement is very great, it may project forward so as to rest on the cuneiform bone. It shifts to the outer margin or on to the cuboid or inward along the margin of the scaphoid, with the character of the lateral displacement of the foot: these dislocations result from torsion of or wrenches of the foot. The foot is shortened anteriorly; the head of the astragalus is prominent. If the foot is displaced outward, it is also everted, and the internal malleolus is prominent; but if the foot is to the inside, it is inverted and the external malleolus is prominent. It is said that sometimes the tibial tendons grasp the head of the astragalus in such a way as to make reduction difficult, or the posterior margin of the astragalus may be caught in the groove of the calcaneum and be difficult to dislodge. The leg should be flexed on the thigh, and extension and manipulation of the foot resorted to in the effort at reduction.

The *astragalus may be dislocated* from the tibio-fibular articulation, as also from the calcaneo-scaphoid attachment. It occurs as a result of falls upon the foot or of twists or wrenches of the foot. The forward

and outward displacement is most frequent. The foot is in full plantar flexion when it occurs. The head of the bone is prominent, the foot is inverted or everted, making prominent one malleolus or the other. *Backward* dislocation is very rare, and is produced when the foot is in extreme dorsal flexion. Outward and inward dislocation is very rare, as is also the dislocation of the astragalus about its own axis. In this displacement the version may be complete, the upper surface looking downward and the lower upward.

Reduction of the dislocation of the astragalus is not always possible. If it can be perfectly accomplished, the functional result may be good, but if it is not possible, primary resection is the safest procedure. Amputation may become necessary.

Dislocation of the tarsal bones may occur.

The DIAGNOSIS is not usually very difficult. If they can be pushed into place, they may recover their function, but if the injury is compound or if it suppurates, then the bone should be removed.

The *metatarsal bones* may be dislocated. The first and second alone are in conjunction with the others. The third, fourth, and fifth are not separately dislocated, but may be associated in a dislocation. They can be forced into position, and if extensive injury does not complicate the case, the recovery is usually with a good foot.

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